



SELINUS UNIVERSITY
OF SCIENCES AND LITERATURE

**SMART OUTPATIENT DELIVERY FOR
GOVERNMENT HEALTHCARE CENTERS IN
SUB-SAHARA AFRICA**

By

Collins Yeboah

2022

Acknowledgements

First and foremost, I want to express my gratitude to the Almighty God for his guidance and assistance. Thank you, Florence Yeboah, for your prayers and emotional and financial aid.

Secondly, because of this, my two children are also to be commended for understanding that their father would no longer be able to play with them during the study period. Finally, I highly appreciate everyone who prayed for and inspired me to get my Ph.D.

Dedication

I dedicate this research to the Almighty God, the owner, and giver of knowledge. Without him, I deserve not to be at this stage of my educational ladder.

I also dedicate this research to my late mother, Dora Acquah, who suffered a stroke while waiting in a queue to see the Doctor. After waiting for about 3 hours to enter the consulting room. The Doctor requested a scan located approximately 30 minutes from the hospital. Overall, the scan result got to the Doctor in 2 hours. Unfortunately, she entered the consulting room in a wheelchair with a stroke. This topic touches my heart because of her. May her beautiful soul rest in perfect peace.

Declaration

Because I am the only author of this thesis, I certify that its contents are solely based on my own research and readings. My dissertation, "Smart Outpatient Delivery for Government Healthcare Centers in Sub-Saharan Africa," is my own work and has not been used to get a degree, an associateship, or a fellowship.

The research papers published due to the study are not plagiarized.



Collins Yeboah

(The Researcher)

Student No: UNISE1874IT

Abstract

CNN Business' Nell Lewis reports that the World Bank says Sub-Saharan Africa has the world's poorest healthcare on average.

Only 3% of the world's health workers and 1% of the global health budget are combating this condition, which is responsible for a quarter of all disease-related disabilities and death (Lewis, 2019).

The weak infrastructure makes it difficult to get even the most basic medical treatment. However, these obstacles are being broken down by new technology such as drones, smartphones, and computer-controlled vending machines, making it easier for more individuals to access life-saving drugs. That is a great time to be a healthcare innovator.

There is an urgent need for better healthcare delivery models due to rising healthcare expenses and the country's per capita spending ranking among the world's highest.

Telemedicine and remote monitoring influenced by COVID-19 have pushed the boundaries of healthcare.

Healthcare innovation is essential for improving patient care, enhancing safety, increasing efficiency, and reducing costs. For example, new ideas in hospital discharge processes need to alleviate bottlenecks in the patient discharge process and countless other essential concerns.

Innovative solutions should be data-driven and evidence-based, leading to high-quality healthcare delivery choices (Holder, 2021).

Implementation of digital health systems is critical to allow patients to obtain treatment from the convenience of their own homes or workplaces. However, there is a perception that Doctors in private hospitals are more advanced than their peers in public hospitals in Africa.

The government hospitals have the know-how, and private hospitals employ these professionals to work part-time at their facilities. As a result, private patients go to private hospitals to obtain better treatment in a shorter time.

Consultation fees and other services depend on the treatment received at private hospitals. However, because of the high volume of patients that attend the government outpatient department each day, it has become almost impossible for the medical staff to provide high-quality treatment.

A Smart OPD System that may assist health personnel limit the number of patients they see is thus necessary. In the wake of the Covid-19 epidemic, physicians, nurses, and patients will all be able to practice medicine without fear.

Reasons for Choosing the Topic

As a result of lengthy waits at public health facilities, patients and health care providers alike encounter difficulties. The Smart OPD system is to alleviate these issues.

For many people, the notion that private hospitals provide better treatment than state-run facilities contributes to the view that private hospitals are used mainly by the wealthy and middle-class. In contrast, state-run facilities tend to be used by the poor. In addition, private hospitals' fees depend on their facilities' quality rather than the caliber of their physicians.

We see many of the same physicians at public and private hospitals. Everything else is the same as before, except for the current technology. The usage of Electronic Health Management Systems (EHM) has allowed private hospitals to revolutionize their operations, allowing them to attend to their patients in a shorter period.

To get a patient's medical data, authorities at our government hospital must first request a hospital card from the patient. Then, a first-in-first-out (FIFO) approach allows the folders to enter the consultation room. Since there are many patients in public hospitals, it takes four hours for them to go through the record, consultation, laboratory, and pharmacy cycle at the public hospitals. On the other hand, patients at private hospitals have to wait 30 minutes to an hour for the same experience.

Research Expectations

Case studies and review of published materials on hospitals' performance in other parts of the world as a foundation found that governments in Sub-Saharan Africa may recognize the benefits of modernizing their hospitals to reduce patients' waiting time at the OPD. This case study illustrates how modernization is coping with today's pressing problems.

Technology may alter the Outpatient Operation to provide speedy and excellent service to patients, enhance efficiency, increase income, and provide opportunities for nurses who cannot find jobs after completing their training. The researcher wants African governments and public health executives to understand that using new healthcare technology is not a waste but an opportunity to improve their operations. Therefore, the Ministry of Health examines relevant digitalization or transformation strategies to encourage investment in efficient and effective systems.

With Oregon Medical Group, Oklahoma University Medical Center, and St. Vincent Healthcare as case studies, the researchers' goal is to utilize these case studies to demonstrate how healthcare modernization tackles current legacy issues. The OPD operational procedures focused on all three case studies, which examined general outpatient care, laboratory, and pharmacy wait times. These departments work together to determine how fast or slow a patient spends in the outpatient department.

In the first case study, Oregon Medical Group planned to build a 46,000-square-foot outpatient facility. Hospital-owned clinics ran 16 separate clinics, although all patients had to check in at a single registration room. As a result, the floor structure, which does not permit the use of an existing medical flag system, would be impacted, as would wait times and resource allocations.

This research's second case study, which focuses on patient care, examines laboratory services. Studies done at 12 hospitals in Texas and Oklahoma found that poorly operated laboratories might delay critical clinical decisions in A&E and other hospital departments where patients need life-saving medical treatment and affect patients' length of stay (LOS)."

Increasingly, medical practitioners rely on the laboratory for verbal findings and test orders, which strains the lab's resources.

St. Vincent Healthcare was the subject of case study 3. St. Vincent Healthcare operates Wheatland Memorial Hospital, a 25-bed critical access hospital in Wheatland. Only 1.6 people per square mile live in Harlowton, a town of 900 people in a county of 2,400. The Harlowton retail pharmacy shut down in May of that year. Wheatland Memorial's 45-mile distance from the pharmacy made it inaccessible to its inhabitants. Visitors prefer to travel to hospitals to get their medications; hence Wheatland Memorial's clinic saw a 17% drop in patients once the pharmacy closed.

According to the findings, the smoothed efforts to deal with the legacy issues had beneficial effects. All things considered;

1. Oregon Medical Group employed a real-time location system to solve a workflow problem. It tracks patients and workers using asset tracking software for room location. As a result, the healthcare workflow solutions reduced patient wait times by 75% while increasing treatment times by 50%.
2. Thanks to robotics and computer technology, TAT testing has been phased out of Oklahoma University Medical Center's lab. As a result, K+ outlier rates decreased from 18% to less than 3% in just nine months on several chemistry exams. In addition, all specimens were tested in real time to prevent the need for TAT testing.
3. Management at St. Vincent's Hospital came up with a new plan of attack when a challenge confronted them. Tele pharmacy Solutions enabled three independent bar code checks to guarantee the correct supply of medication to the valid patient. In addition, patients at St. Vincent's Hospital could video call pharmacy staff. Thanks to these strategies, people in the neighborhood had an easier time getting the pharmacological treatment they needed. An additional perk of this position is allowing a more hands-on approach to patient treatment. Prescriptions were filled in as little as ten minutes at the Wheatland Memorial pharmacy, allowing patients to go back on their way in record time.

The modernization model aspires to illustrate how technology may transform the OPD operation in government healthcare facilities, promote efficiency, and generate income. Instead of perceiving modernization as a cost, government and public healthcare administrations should recognize the benefit of bringing their current systems up to date and best-practice standards.

Because of this study's findings, governments in Sub-Saharan Africa must invest in efficient and effective systems by looking into appropriate digitization efforts.

The hypothesized path

Outpatient care in public health must be reorganized, according to this argument. This part also discusses modernization and business benefits. The study's review of already-in-place, tried-and-true models and procedures may also assist public hospitals.

The case study method is helpful for both this thesis and its application. With a case study, researchers can see the problem from the perspective of the people affected by it. Stakeholder interviews and document and artifact analysis were acquired this information and direct observation. The recommendation relies on the gathering and analysis of relevant data. For example, a country in Africa that wants to enhance its healthcare delivery may benefit from this study's results and suggestions.

Table of Content

Contents

| | |
|--|------|
| Acknowledgements..... | ii |
| Dedication..... | iii |
| Declaration..... | iv |
| Abstract..... | v |
| Reasons for Choosing the Topic..... | vi |
| Research Expectations..... | vii |
| The hypothesized path..... | x |
| Table of Content..... | xi |
| List of Figures..... | xiv |
| List of Tables..... | xvi |
| List of Abbreviations..... | xvii |
| Chapter 1: Introductory Chapter..... | 1 |
| 1.1 Overview..... | 1 |
| 1.2 Background..... | 2 |
| 1.3 Problem Statement..... | 5 |
| 1.4 Research Questions..... | 6 |
| 1.5 Research Methods..... | 6 |
| 1.5.1 Case Study Design..... | 7 |
| 1.5.2 Data Collection Methods and Sources..... | 7 |
| 1.5.3 The structure of the thesis..... | 8 |
| Chapter 2: Literature Review..... | 9 |
| 2.1 Revolution in Healthcare..... | 9 |
| 2.2 How new tech can propel Africa to the forefront of healthcare..... | 14 |
| 2.3 Healthcare Infrastructure..... | 17 |
| 2.3.1 The built environment..... | 18 |
| 2.3.2 Medical equipment..... | 19 |
| 2.3.3 Access..... | 21 |
| 2.3.4 Technology..... | 23 |

| | |
|--|----|
| 2.3.5 Governance and organizational infrastructure | 25 |
| Figure 2.3 Ministry of Health's ties to Ghana's numerous industries and organizations. | 27 |
| 2.3.6 Staff structures | 30 |
| 2.3.7 Sustainable healthcare..... | 35 |
| 2.4 Case Studies | 38 |
| 2.4.1 Outpatient Workflow Automation at Oregon Medical Group (Case Study 1)..... | 38 |
| Figure 2.10: Automation through RTLS can transform patient care. Source: healthcare facilities today.. | 38 |
| 2.4.2 laboratory case study: the hospital's most critical department? (Case Study 2)..... | 40 |
| 2.4.3 An Automation Solution for Rural Outpatient Pharmacy Services (Case Study 3)..... | 44 |
| Chapter 3: Operational Framework..... | 48 |
| 3.1 WHO and UNICEF Framework | 48 |
| 3.2 Public Healthcare Delivery: Ghana's Case | 52 |
| 3.2.1 Prospects | 52 |
| 3.2.2 Challenges..... | 54 |
| 3.3 Functional Analysis | 54 |
| 3.3.1 Operational Processes | 58 |
| 3.4 Functional Diagrams | 60 |
| 3.4.1 Doctors and Nurses | 64 |
| 3.4.2 Laboratories and Pharmacies | 65 |
| 3.4.3 Payment Options..... | 66 |
| 3.5 Platforms | 67 |
| 3.5.1 Mobile Health | 67 |
| 3.5.2 Electronic Health Records | 69 |
| 3.5.3 Virtual Hospital..... | 69 |
| 3.5.4 Telemedicine..... | 70 |
| 3.5.5 AI in Healthcare | 72 |
| Figure 3.6: All-in-one clinical decision support | 76 |
| Figure 3.7: AI-enabled drug information reference database | 77 |
| Figure 3.8: AI clinical decision support for imaging | 77 |
| Chapter 4: Evaluation, Control, and Discussions | 79 |
| 4.1 Delivery Management..... | 79 |
| 4.1.1 Delivery to the cloud..... | 79 |
| 4.2 Evaluation and Control | 81 |
| 4.2.1 Performance and Availability | 82 |
| 4.2.2 Reliability and SLAs..... | 83 |
| 4.2.3 Technology Stack and Cost..... | 83 |

| | |
|---|-----|
| 4.2.4 Security and Compliance | 84 |
| 4.3 Stakeholder Analysis | 86 |
| 4.4 Discussions | 94 |
| 4.4.1 Doctor’s point of view | 94 |
| 4.4.2 Pharmaceutical point of view..... | 94 |
| 4.4.3 Nurse’s point of view | 95 |
| 4.4.4 Entrepreneurial point of view | 95 |
| Chapter 5: Summary, Conclusion, and Recommendations | 97 |
| 5.1 Summary | 97 |
| 5.2 Conclusion | 99 |
| 5.3 Directions for Future Research | 101 |
| 5.4 Recommendations..... | 101 |
| References | 103 |

List of Figures

Figure

1.1 Infant Mortality Rates per 1,000 lives in 2019

1.2 Patients wait in line for the pharmacy at Neno District Hospital, Malawi

2.1 Drone delivering blood for transfusions makes its maiden landing near Kigali, Rwanda.

2.2 Digital health solutions and treatments.

2.3 Ministry of Health's ties to Ghana's numerous industries and organizations.

2.4 The Ghana Health Service has several divisions.

2.5 Nurses and Midwives per 1,000 people in 2018

2.6 Physicians per 1,000 people in 2017

2.7 Skilled health professional density per 10,000 by African sub-region, various years.

2.8 Nurses who entered the training scheme had to commit to staying in Ghana for five years after qualifying.

2.9 Conceptual framework of sustainability of interventions implemented in SSA.

2.10 Automation through RTLS can transform patient care.

2.11 Lab Automation.

2.12 Pharmacy Automation.

3.1 Primary healthcare components.

- 3.2 Shows the business process of the problem condition.
- 3.3 Shows the Business process of the desired condition.
- 3.4 Process flow of the desired payment system.
- 3.5 Network Infrastructure of the desired system.
- 3.6 All-in-one clinical decision support.
- 3.7 AI-enabled drug information reference database.
- 3.8 AI clinical decision support for imaging
- 4.1 Sizing Cloud Shift, Worldwide 2019 – 2025
- 4.2 Cloud security strategy across different types of cloud services providers

List of Tables

Table

3.1 Overview of Primary healthcare levers.

3.2 A3 Report and a Functional Analysis of public healthcare delivery in Sub-Saharan Africa.

4.1 Stakeholder analysis of the Smart OPD project.

List of Abbreviations

| | |
|--------------|--|
| FIFO: | First-In-First-Out |
| OPD: | Outpatient Department |
| A&E: | Accident and Emergency |
| LOS: | Length of Stay |
| TAT: | Turn Around Time |
| K+: | Potassium |
| IOM: | Institute of Medicine |
| WHO: | World Health Organization |
| CEO: | Chief Executive Officer |
| NHII: | National Health Information Infrastructure |
| WEF: | World Economic Forum |
| ComCHIP: | Community Chip Compound |
| SMS: | Short Message Service |
| NCD: | Non-Communicable Diseases |
| 4IR: | Fourth Industrial Revolution |
| AI: | Artificial Intelligence |
| 3-D Printer: | Three-Dimensional Printing |
| IoT: | Internet of Things |
| IT: | Information Technology |
| UN: | United Nations |
| CT scanner: | Computerized Tomography Scan |
| MRI: | Magnetic Resonance Imaging |
| IFC: | International Finance Corporation |
| SIM: | Subscriber Identity Module |

| | |
|-----------------------|--|
| MoH: | Ministry of Health |
| GHS: | Ghana Health Service |
| BBC: | British Broadcasting Corporation |
| NHS: | National Health Service |
| MEDLINE: | Medical Literature Analysis and Retrieval System Online |
| CINAHL: | Cumulative Index to Nursing and Allied Health Literature |
| Embase: | Embase is a biomedical and pharmacological bibliographic database of published literature designed to support information managers and pharmacovigilance |
| PsycInfo: | Database of abstracts of literature in the field of psychology |
| SCIELO: | Scientific Electronic Library Online |
| HIV/AIDS: | Human immunodeficiency virus infection and acquired immune deficiency syndrome |
| SSA: | Sub-Saharan Africa |
| DSF: | Decision Support Framework |
| PEN-3 cultural model: | consists of three primary domains: (1) Cultural Identity, (2) Relationships and Expectations, and (3) Cultural Empowerment. Contextualizes the role of culture in shaping understanding of and actions towards health and illness. |
| RTLS: | Real-Time Location System |
| EHR: | Electronic Health Records |
| EHM: | Electronic Health Management Systems |
| RFID: | Radio-Frequency Identification |
| OUMC: | Oklahoma University Medical Center |
| TLA: | Total laboratory automation |
| POC: | Point-Of-Care |
| TAT OP: | Turn Around Time, Outlier Percentage |
| TLA: | Total Laboratory Automation |
| UNICEF: | United Nations International Children's Emergency Fund |
| WHA: | World Health Assembly |

| | |
|----------|---|
| SDGs: | Sustainable Development Goals |
| PHC: | Primary Health Care |
| HSPA: | Health System Performance Assessment |
| PHU: | Public Health Units |
| GPRS: | General Packet Radio Service |
| PPPM: | Predictive, Preventative, and Personalized Medicine |
| HIPAA: | Health Insurance Portability & Accountability Act |
| mHealth: | Mobile Health |
| ML: | Machine Learning |
| NLP: | Natural Language Processing |
| DL: | Deep Learning |
| ER: | Emergency Room |
| SME: | Subject Matter Expert |
| CDS: | Clinical Decision Support |
| IBM: | International Business Machines |
| SLA: | Service Level Agreement |
| PaaS: | Platform as a Service |
| CSPM: | Cloud Security Posture Management |
| SASE: | Secure Access Service Edge |
| CASB: | Cloud Access Security Broker |
| CWPP: | Cloud workload protection platform |
| DEM: | Digital Elevation Model |
| CSR: | Corporate Social Responsibility |
| VRA: | Volta River Authority |

Chapter 1: Introductory Chapter

1.1 Overview

"Timeliness" is one of six "aims for improvement" listed by the Institute of Medicine in its most current report on quality. Nevertheless, patients' discontent and worsening health outcomes are some of the results of delays in care (Green, 2008).

In today's healthcare system, there is an abundance of holdups. As a result, timeliness was designated as one of six main goals for development in 2001 by the Institute of Medicine (IOM), the leading advisory organization for government and the commercial sector on health-related problems (Green, 2008).

To begin therapy, we must wait a long period to see a doctor or have surgery scheduled because of mounting evidence that significant delays in the healthcare industry significantly affect patient results.

The researcher in this study is looking for the underlying causes of the potentially deadly lags. In addition, develop an innovative approach that might substantially influence how quickly patients in the Outpatient Department can get medical attention.

The researcher wants to show how healthcare modernization addresses legacy challenges using Oregon Medical Group, Oklahoma University Medical Center, and St. Vincent Healthcare as case studies. For example, case studies on general outpatient care and laboratory and pharmacy wait times were the subjects of OPD operating processes.

1.2 Background

A total of 29,741,608 persons attended all public health institutions' outpatient departments (OPDs) in Ghana in the year 2016, compared to 29,949,173 in 2015, and 31,087,824 in 2014 (GHS, 2017).

Many Nigerians have difficulty accessing affordable, high-quality primary and urgent health care services. High costs and long travel distances to medical institutions may be stumbling blocks to getting the treatment needed. As a result, many sick children and adults do not receive the proper medical attention they require.

An investigation by WeBelieve Health and NOIPolls Limited indicated that 88% of Nigerians and members of their families have recently been to a medical facility. More than half of Nigerians (53%), 43% of pharmacists, and 34% of private hospitals visited several facilities recently. Gender and age groups seem to have no substantial impact on choosing a medical facility. On the other hand, public hospitals in the northeast and northwest of the nation witnessed many patients (NOI Polls, 2018).

Available statistics show that more than 40% of WHO Member States report fewer than ten doctors per 10,000. (Over 26% reported having less than 3 of them). Moreover, health workers have spread unevenly across the globe. Countries with the lowest relative needs have the highest number of health workers, while those with the highest disease burden have fewer health workers. More than 22% of the global illness load is borne by Africa, although just 3% of the world's health personnel and fewer than 1% of its financial resources are available (WHO, 2020).

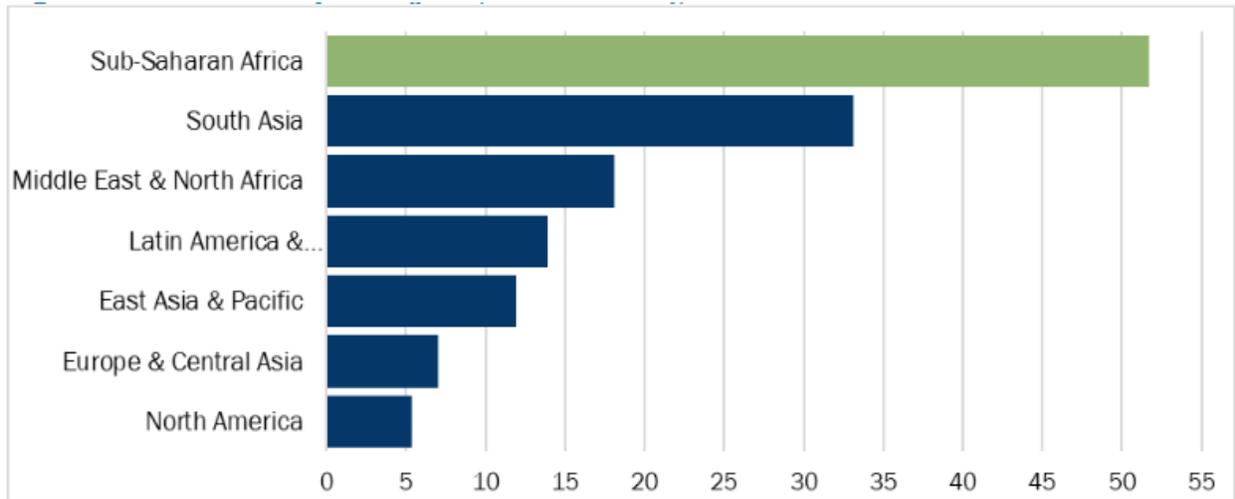
Below are the physicians to 10,000 population ratios according to the World Health Organization in some West African countries.

- a) Benin – 0.79
- b) Burkina-Faso – 0.85
- c) Ghana – 1.36
- d) Ivory Coast – 2.31
- e) Liberia – 0.38
- f) Nigeria – 3.81
- g) Sierra Leon – 0.25
- h) Togo – 0.77

For patient-doctor encounters to fulfill WHO standards in Nigeria, the country will require roughly 300,000 physicians, according to the National University Commission (Igoni, 2020).

The result is long waits for outpatient appointments at government hospitals and health clinics (about two hours on average). In addition, errors and poor communication are common when physicians are under pressure. As a result, physicians do not interact effectively with patients and sometimes make mistakes due to fatigue when working under pressure. That is part of the outcome of Sub-Saharan Africa's leading infant mortality rate compared to other regions, as shown in the chart below.

Figure 1.1: Infant Mortality Rates per 1,000 lives in 2019



Source: World Health Organization, extracted from African Growth Initiative at Brookings

In the north, Tanzania and Mozambique border the country of Malawi, a patient was admitted to the hospital while pregnant with rheumatic heart disease. Patients in her circumstances "usually cannot scale a flight of steps," according to the country's clinical director for Partners In Health. On arrival at the clinic, Nimiya (the patient) had walked for seven hours." (Partners In Health, 2017).

Figure 1.2: Patients wait in line for the pharmacy at Neno District Hospital, Malawi



Patients wait in line for the pharmacy at Neno District Hospital, Malawi. Source: Partners in Health

It is predicted in a recent analysis by Moody's Investor Service that outpatient care will become increasingly important in the healthcare business in the future, which is good news for both traditional hospitals and outpatient facilities as their care standards evolve (Naim, 2018).

Outpatient departments in Sub-Saharan Africa may swiftly adapt their operations to provide better OPD treatment if they can generate income and increase operational efficiency via digitally transformed public health facilities.

1.3 Problem Statement

Several studies have demonstrated congestion in clinics to have adverse effects studied in several methods. For example, patients and employees might be utilized as subjects to examine these effects. Overcrowding is associated with poor patient outcomes, staff burnout, discontent, nosocomial infections, mortality, poor patient outcomes, increased medical errors, and reduced patient safety (Bahadori et al., 2017).

Increased access to outpatient therapy has resulted in an unforeseen consequence: overcrowding in outpatient clinics. The researcher in this study set out to discover a solution to the congestion issue in outpatient clinics.

Long delays at the hospital have impacted many families and social network members. Many people complained about long waits at hospitals and missed appointments with doctors. In addition, while waiting in line due to poor queue management, someone else may be allowed, and so on (Kanini, 2016).

This paper will indicate that IT funds will be needed to implement the innovative strategy that this thesis advises. Licensing costs continue to climb, as do the costs of employees who will manage the system. An increasing burden on the company's finances prevents investment in new ideas and activities.

1.4 Research Questions

Public healthcare facilities in Sub-Saharan Africa are looking for ways to improve the efficiency of their business operations to reduce or eliminate wait times in the Outpatient Department. To address this challenge, the researcher will also look at some operational issues, including:

1. Current system issues for hospital administrators?
2. Are the government and stakeholders concerned about innovation?
3. The outcome of investing in new technology and retooling outdated procedures.

Due to lengthy waits at OPD, this research evaluates the obstacles and advantages of modernization programs in public healthcare. It will also offer innovative solutions for public healthcare institutions in Sub-Saharan Africa to use while implementing creative projects.

1.5 Research Methods

The research method selected was a case study approach to explore and resolve the problem. A case study can help better understand more complicated situations or things since it builds on previous research.

The social sciences have used qualitative research extensively to investigate current real-world situations. Since it has become the foundation, new concepts and methodologies have emerged.

1.5.1 Case Study Design

Researchers believe that case studies can help them better understand complex circumstances. Equipped with firsthand expertise, the research group offers possible answers when confronted with challenges. Rigorous planning, thorough research, and careful participant selection help overcome the difficulties of conducting case studies (Salmon, 2017).

The case study will depend on three destined areas as follows;

- A case study on outpatient wait time
- A case study on pharmacy automation and home delivery
- A case study on clinical laboratory automation

1.5.2 Data Collection Methods and Sources

To gather information for this case study, we used project documents, online publications, and yearly reports to perform an As-Is (state before modernization) examination of the legacy environment, project goals, and milestone deliverables. The investigation began with the project documentation, including but not limited to the As-Is assessment report, project initiation papers, and rationale and objectives for modernization (business cases). Next, the

researcher used strategy papers, project management reports, and project milestone deliverables to determine the best path for modernization.

1.5.3 The structure of the thesis

Following the thesis are three case studies on patient wait times in the OPD, laboratory, and pharmacy and a literature review in Chapter 2.

This book's third chapter looks at current infrastructure, materials, and techniques, with a flowchart diagram of existing and future healthcare modernization plans. Please refer to Chapter 4 for a summary of findings and solutions. It will also study employment generation as a result of the project. Finally, in chapter 5, the subject is summarized with results and recommendations.

Chapter 2: Literature Review

This study looks at healthcare revolutions, how new technology can catapult Africa to the forefront of healthcare, and the current healthcare infrastructure. The researcher will also examine a case study in the outpatient healthcare delivery system.

2.1 Revolution in Healthcare

Considering that more people opt for outpatient treatment, are healthcare providers gearing for a "revolution"? When it comes to (H. J. Anderson and coworkers, 1990),

Outpatient executives are using some of these strategies with the support of T. Hudson and P. Eubanks. The United States is home to many hospitals, ranging from massive university medical institutions to tiny rural ones. Aside from corporate strategy, the story of outpatient care does not end. The need for outpatient management skills is a top priority for health care leaders. However, according to outpatient executives who have worked in the area for many years, substantial differences in management expertise might either make or break a hospital's outpatient services. As what it takes to be a successful CEO of an outpatient services organization develops, some experts feel that it may also serve as a model for other aspiring CEOs in the healthcare industry, both within and outside hospitals.

The US healthcare system consists of many healthcare providers (physicians, hospitals, and other healthcare facilities), insurance plans, and consumers. The public sector is home to some, while the private sector is home to others, non-profit or for-profit. Health care regulators may be government or non-profit organizations. The phrase "healthcare delivery system" suggests an order, integration, and accountability that does not exist among these varied individuals and organizations. Coordination, collaboration, and system planning are severely lacking among these multiple institutions.

Despite the importance of health care, it is not the only determinant determining one's health (H J Anderson et al., 1990).

For most Americans, regular access to medical care means health insurance, whether from a private company or a government-funded program. Having health insurance coverage is connected to better health outcomes for people. A frequent source of care and a more prominent and appropriate utilization of health services are also connected.

The number of patients at public hospitals has risen since many individuals seek a regular care source and more significant and more efficient usage of health services. '

Americans are living longer because of improved treatment for chronic ailments. Life expectancy for today's children is rising over 75 years, and medical advancements have also boosted the lifespans of previous generations.

There must be a coordinated effort between patients and healthcare providers to develop a care strategy that includes objectives, targets, implementation strategies, sustained follow-up for in-person visits, phone calls, emails, and web-based monitoring and decision support systems.

Wagner and colleagues (1996), cited by H. J. Anderson, T. Hudson, and P. Eubanks, emphasized the importance of the following five factors in improving outcomes for patients with chronic illnesses:

Practice evidence-based reorganization on planning for patients who need more time, resources, and frequent follow-ups. Care for the aging population, balancing spikes in demand for emergency treatment, and dealing with a large-scale disaster like a terrorist attack are all impossible with the current state of healthcare resources.

According to the authors, assessing access to primary care without considering the current insurance and care delivery system inefficiencies is impossible. Hospital emergency and outpatient departments may strain by uninsured persons who do not have health insurance. Individuals and their families get their leading healthcare from primary care providers, making it distinctive. The characteristics of successful primary care are continuity of care across treatment levels, comprehensiveness of services customized to the patient's condition, and enhanced long-term coordination (H J Anderson et al., 1990).

Hospitals and other service providers can only enhance their services using modern information technologies. For example, information technology might assist patients and caregivers make critical health decisions, encourage individual and population-based preventive programs, and improve public health engagement and collaboration.

Public health monitoring and disease surveillance activities need a sophisticated health information system. System and process integration is crucial for detecting emerging health risks and assisting all stakeholders in making informed decisions. If the healthcare sector undergoes the same digital transformation as banking and other industries, then building an NHII should be a national priority.

These three domains found health care delivery and government public health agencies interwoven. Under this umbrella are everything from health care providers to the government to health monitoring to the provision of safety net services. Therefore, health care delivery systems and government health agencies should work together to improve the health of individuals and assist other public health system players via enhanced collaboration and integration.

More than 2.4 billion people will live in Africa by 2050, with some countries expanding their populations by three times during the previous twenty years. Africa has the highest population increase. In addition, many individuals are in their twenties across the continent, which bodes well for the region's economic future.

90% of Africa's workforce is employed by the private sector, accounting for around 45 percent of overall production, two-thirds of investment, and three-quarters of all lending. Investing in the healthcare business in Africa is an excellent opportunity because of the growing population and the growing middle class that is willing to pay for healthcare. As a result, we achieve optimum efficiency and productivity via investments and the private sector or government alone (Africa Health Business Symposium, 2017).

According to the findings of this study, an international partnership between public, private, and development partners is vital to encourage investment in long-term healthcare outcomes and optimize investment returns while strengthening the African healthcare sector.

Thanks to the private sector's technical prowess and skills, it may be possible to gain from healthy competition in the public sector. Moreover, investing in cutting-edge technology would help the developing world to leapfrog the progress made by the affluent world over a while. Dial-up internet service is outmoded in developed countries, for example.

A recent investigation by the World Economic Forum (WEF) has discovered that the top healthcare spenders in the world are not necessarily obtaining the best value for money. At the same time, other nations' health systems can provide comparable or better results for much less money, the report says. The aim is possible by developing a robust primary care system focusing on the patient, employing technological innovations to keep prices down, and allocating resources efficiently (Africa Health Business Symposium, 2017)

Journal of Health Affairs released an article saying healthcare must be cost-effective rather than expensive. In addition, this year's Africa Health Business Symposium drew attention to five critical healthcare reform issues across the continent: Investing in healthcare, developing human resources for health, Supply chain management, and using digital technologies are all instances of healthcare finance.

Connectivity-based digital technology breakthroughs have affected every industry. According to the paper's results, researchers at Harvard Business School rightly said that "this paradigm is not displacement and replacement, but connectivity and recombination," according to the paper's results.

Analysis revealed that the justification for sustainable health systems is not just a moral problem of providing treatment to everyone, but more importantly, it is an economic one. That is because investment in health care might lead to a healthy economy capable of promoting economic growth.

Many African workers will soon be young and healthy, which will help the continent's economy in the long run. However, one of the pieces in the newspaper asked, "Do we need wealth for health or health for wealth?"

2.2 How new tech can propel Africa to the forefront of healthcare

According to a blog post by Patrice Matchaba from Novartis, Africa's healthcare systems are rapidly improving, and the fourth industrial revolution may take root.

Because of the ComCHIP effort in countries like Ghana, patients with high blood pressure no longer must go to regional hospitals, which are sometimes overcrowded and out of reach.

African community nurses benefit from mobile devices and telemedicine, which allow them to communicate with community healthcare workers and physicians as necessary. SMS and voice messaging can educate patients, lower cardiovascular disease risk factors, and increase medication compliance. Drone-delivered blood transfusions are now available in Rwanda for the first time. Currently, Tanzania and Ghana are employing a similar form of business.

Figure 2.1 Drone delivering blood for transfusions makes its maiden landing near Kigali, Rwanda.



Drone delivering blood for transfusions makes its maiden landing near Kigali, Rwanda. Source: REUTERS/James Akena.

As Novartis' Patrice Matchaba points out, "Many African nations are moving towards universal health coverage based on an efficient, equalitarian and creative primary care system." She went on to say that the European Union and the United States may adopt lean technology developed in Africa and other developing nations.

Emerging countries have a high potential to lead the way in "bottom-up" healthcare (Matchaba, 2018).

To combat Africa's "dual-disease burden" of NCDs and infectious illnesses, the World Economic Forum recommends shifting toward low-cost and high-quality medical systems that encourage individuals to take responsibility for their health. Then, using mobile technology and individualized treatment, we will be able to achieve our goals."

Professor Landry Signé, a senior fellow at the Brookings Institution and managing director and professor at Thunderbird School of Global Management, penned an article titled "Strategies for Successful Health Care in Africa in the Fourth Industrial Revolution." He cited the high incidence and mortality rates of infectious and non-communicable diseases as evidence that Africa's efforts to improve health outcomes in recent decades have a long way.

Regarding healthcare, Africa's healthcare business may benefit greatly from the investments and technological advancements of the Fourth Industrial Revolution (4IR). That includes utilizing disruptive technologies like artificial intelligence (AI), machine learning, and big data analytics. There are several instances of disruptive technologies, including 3D printing, the Internet of Things (IoT), self-driving vehicles and drones, the cloud, and blockchain technology. As a result, investment in health-related 4IR technology offers significant advantages in both economic success and preservation of human rights (such as health).

According to a published article, these are Professor Landry Signé's seven efforts for altering healthcare in Africa.

1. A national task force should be established to devise (and help implement) vertical and horizontal strategies and processes relevant to local and national contexts while benefiting from foreign ideas and experiences to deliver on the promise of health care in Africa.
2. 4P partnerships may help small, local health organizations and entrepreneurs by fostering risk pooling and increasing their access to funding.
3. Training medical professionals in e-learning tactics is a great way to ensure they are ready to employ increasingly advanced technology.
4. To deal with the lack of human capital, the diaspora and allies of Africa can use technology platforms and networks to obtain "digital brain gain."
5. To increase financial access to healthcare and attain universal health coverage, use recent fintech and digital health developments.
6. To hasten the adoption and utilization of 4IR technology, "community health leaders" and local communities should be involved.
7. To provide widespread broadband internet access, invest in health facility electrification.

Meetings between government and business executives examined ways to improve African health outcomes. In addition, during the African Union Summit in Ethiopia in 2019, health forums marked the establishment of ABCHealth. This private sector company aims to assist government efforts to change healthcare provision in Africa.

Aigboje Aig-Imoukhuede, a co-founder of the African Business Coalition for Health (ABCHealth), says, "fix health, and you restore Africa." An accurate image of healthcare in Africa paints in this report. Africa must first improve the health of its people in order to realize its full economic potential.

Healthcare in Africa, despite recent advancements, is still a long way off from the rest of the world (New Africa, 2019).

In addition, the inverse is correct, as all may have guessed. According to previous studies on health in other nations, repairing Africa's health is a no-brainer; hence, fixing Africa's health will solve it.

2.3 Healthcare Infrastructure

For the primary objective of increasing patient care and well-being and creating an enjoyable healthcare experience for all patients, infrastructure is crucial. In addition, the healthcare system and its staff must teach individuals how to prevent sickness and take care of themselves to take charge of their health and well-being.

Because it is a center for acute and inpatient treatment, a hospital's infrastructure must link to the more extensive health care system. It should support the seven quality dimensions of patient experience, efficacy, efficiency, timing, safety, equality, and sustainability. Infrastructure includes the constructed environment and everything that goes with it, including IT, equipment, access, systems, processes, sustainability initiatives, and staff. A patient's situation is unique, but when these considerations, referrals from local hospitals to specialized tertiary facilities and discharge to the correct treatment should be quick and straightforward (either at home or an intermediate-care facility).

Simone Sandhol, a senior scientist at UN University Institute for Environment and Human Security, noted that the ongoing COVID-19 pandemic has made it clear that communities rely on well-functioning healthcare facilities. To prevent a catastrophic event, hospital beds, medical staff, protective gear, and ventilators may make all the difference."

2.3.1 The built environment

Healthcare systems in many African nations do not prioritize education for women and mothers, who are the significant guarantors of their children's welfare and agricultural sustainability. It is deceptive to believe that rural communities are well-served by the national pyramidal health system, which is poor at the village level and disproportionately favors provincial and federal institutions. However, many medical schools on the continent continue to promote outdated and unbalanced European health teaching.

Journalists Around a quarter of the worldwide illness load and a third of the burden in developing countries may be decreased by environmental health interventions or initiatives, according to Dr. Jean Baptiste ROUNGOU and Dr. Maria Neira. As a result, problems including a scarcity of clean drinking water, air pollution (both inside and outdoors), improper waste disposal, a lack of or inadequate disease vector management, and other long-standing risk factors are unaddressed by the WHO's African Region. Additional environmental threats are on the horizon in addition to the current demands on the continent's public health systems. Persistent organic pollutants, electronic waste, radiation, and new occupational risks are a few significant issues we face today and global warming. All these issues can become more serious soon.

This report claims WHO has helped nations build health and strategic environmental agendas and provided technical assistance to countries to support national initiatives to minimize or mitigate the harmful impacts of the environment on human health.

2.3.2 Medical equipment

Successful healthcare systems require the use of health technologies. Medical devices are an example of technology that can diagnose, treat, and rehabilitate sick or disabled people.

Over 10,000 medical devices are listed on the WHO website, ranging from lancets to complex imaging equipment, in vitro tests, and implanted devices. In 2010, the worldwide medical device industry was more than \$250 billion. However, although the medical device industry has grown substantially over the last two decades, it is mainly focused on advanced healthcare systems in high-income nations. Consequently, it has only a limited influence on less advanced rural and primary care institutions in low and middle-income nations (WHO, 2016).

Governments use vaccines worldwide to safeguard populations and turn the tide against COVID-19. Meanwhile, to offer proper care to those who are currently in need, African healthcare providers are in desperate need of critical—but often prohibitively expensive—medical equipment. Private healthcare practitioners are a significant part of the health system in many Sub-Saharan African nations, treating millions of patients.

What is Africa's current situation? According to a WHO study, only 11% of responding African countries had at least one MRI equipment per 1 million inhabitants, while only 24% had at least one CT scanner. On the other hand, MRI machines were found in 62% of Middle Eastern nations and 85% of European countries, while CT scanners were in 86% of Middle Eastern countries and 97% of European countries (IFC, 2021).

The International Finance Corporation (IFC) has responded to Africa's growing need for high-quality medical equipment by establishing the Africa Medical Equipment Facility in collaboration with equipment manufacturers and financial institutions, according to an article published by the IFC in April 2021. The goal is to assist hundreds of healthcare workers in seven African countries—Cameroon, Côte d'Ivoire, Kenya, Rwanda, Senegal, Tanzania, and Uganda—to obtain loans to purchase or lease the needed equipment to offer high-quality care, including everything from lab equipment to MRI machines.

Medical equipment that is appropriate, affordable, and of excellent quality is essential in the healthcare industry. In addition, it aids in disease prevention, detection, and treatment. To support the Global Strategy and Action on Public Health Innovation and Intellectual Property, the World Health Organization (WHO) worked with the European Union to produce this project report on medical device access through local production. The second phase of the LPTTMD project with details in this report and a situational analysis of the constraints to medical device access, knowledge transfer, and local manufacturing in four Sub-Saharan African countries (viz. Ethiopia, Nigeria, South Africa, and Tanzania).

The project's objectives were to promote access to priority medical equipment, provide country case studies, and establish a road map of activities to increase availability and, where possible, investigate local production. Phase II looked at the results of the phase I surveyed regarding access barriers and challenges and utilized the feasibility tool to help choose a device with high public health value for local production.

The World Health Organization (WHO) recommends that more people have access to medical devices to meet healthcare needs (WHO, 2016).

Better product design meets local needs with the help of other professionals who can assist with innovation, research, and development; and appropriately regulating medical devices to implement better procurement processes.

The WHO also hoped that the study and local workshops, which brought together all stakeholders (government, academia, and business), would inspire them to work together to enhance access to appropriate medical equipment to meet local health priorities. As a result, there were expectations that other countries would use similar lessons to enhance the quality of care they give their citizens.

2.3.3 Access

Everyone must access health care services to reach the UN Sustainable Development Goal 3 of universal health coverage. Nevertheless, unfortunately, due to the distance from public hospitals in Sub-Saharan Africa, over two out of every five people do not have access to affordable healthcare (Falchetta et al., 2020).

Low- and middle-income countries in Sub-Saharan Africa have limited access to healthcare services due to poverty, low educational attainment, a lack of healthcare professionals, and inadequate healthcare infrastructures. In addition, medical therapy may be unavailable to patients and caregivers due to economic, cultural, and physical limitations. Therefore, it is crucial to develop sound policies, make the physical environment more accessible, educate the public about disabilities, and gain parental support to access healthcare.

In Sub-Saharan Africa, the coronavirus 2 (COVID-19) that causes severe acute respiratory sickness quickly spreads. Hospitalization for COVID-19 is among the elderly. However, the journey time to the nearest health care facility in sub-Saharan Africa is a significant barrier to accessing medical care. A group of writers in sub-Saharan Africa was interested in finding out how long it would take for someone 60 years of age or older to go to the nearest hospital or healthcare facility.

Across sub-Saharan Africa, 96% of people aged 60 and over had an estimated travel time to the nearest hospital of 6 hours, ranging from 0% in Burundi and The Gambia to 40% in Sudan. Sub-Saharan Africa has 159 percent of the population aged 60 and over who must travel more than two hours to find a health care facility (primary, secondary, or tertiary care). At least 12 hours to the nearest hospital and at least 6 hours for any health care facility were commonplace for persons over 60. Travel time to the nearest hospital ranged from 41 minutes (34–54) in Burundi to 1655 minutes (1065–2440; equal to 276 h) in Gabon for the fifth of persons aged 60 or older with the most incredible travel times (equivalent to 348 minutes).

It is a hope that these maps can aid policymakers and non-governmental groups in their efforts to provide more health care resources, such as temporary hospitals or transportation programs, to the elderly who are most in need. According to this research, people in specific populations are more likely to underreport COVID-19 symptoms due to a lack of physical access to health care facilities. It can also assist countries in improving physical access to care for conditions prevalent among the region's older population, such as COVID-19 (chronic non-communicable diseases).

According to the study, one in ten people over 60 in Sub-Saharan Africa traveled more than six hours to the nearest hospital. Health care accessibility will thus substantially impact the elderly's ability to obtain treatment for COVID-19 in this location.

2.3.4 Technology

For patient management and illness diagnosis and prevention, digital health technologies aimed at bettering healthcare in Sub-Saharan Africa are becoming increasingly popular in that region. Patients, healthcare professionals, health system management, and data services are progressively using digital health solutions and treatments in areas with the highest sickness load and the most acute shortage of healthcare workers. Healthcare in sub-Saharan Africa is prospering because traditional healthcare services are either insufficiently staff- or equipment-equipped or completely unavailable (Sukums et al., 2020).

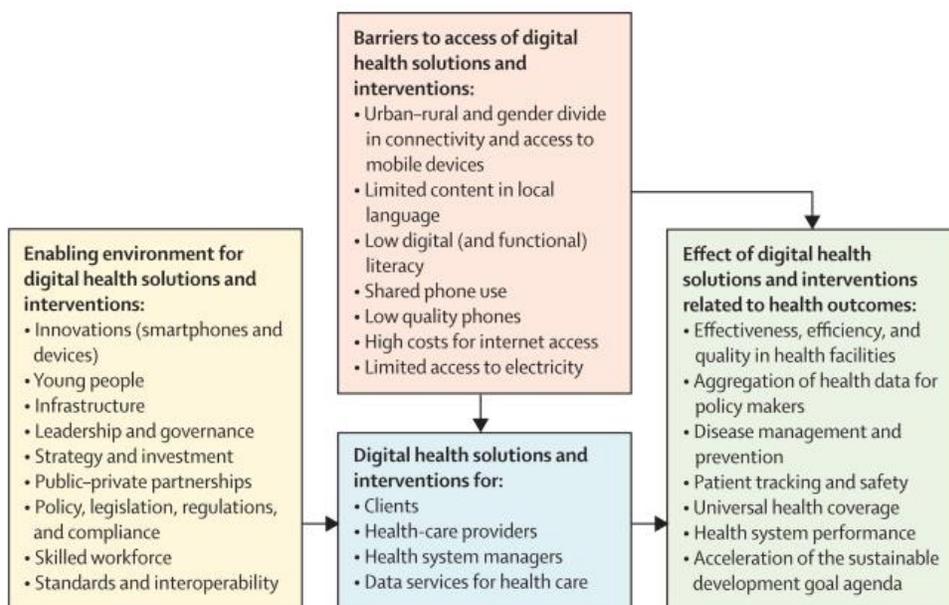
A wide range of digital health technologies is available to consumers today. For example, mobile phones have enabled South Africans to receive maternal health assistance, Ghanaians to identify fake medications, and Kenyans to use a digital health-financing platform. Using social media and telemedicine for health promotion is prevalent in the region. In addition to enabling innovative, affordable, and portable diagnostic devices, wearables, sensors, and IoT systems and wearables have made it possible to track and monitor people's health in a hospital or remote locations. Many ailments in Sub-Saharan Africa might benefit from big data and artificial intelligence, which have already shown useful in epidemic management and planning.

Better supply chain management decisions have been made due to enhanced visibility of logistical data at all levels of the supply chain, including primary healthcare, resulting in fewer stockouts (e.g., in Uganda). A new school in Malawi teaches students about drones and data because they are increasingly used to transport blood and other supplies between medical facilities. Community health workers in sub-Saharan Africa may now use apps that interface with national vital registration systems. For example, District Health Information Software 2

gathers data from health facilities and communities to track and evaluate illness trends, demographics, and outbreaks.

An estimate shows that by 2025, mobile phones will account for 66% of all SIM connections. According to a recent estimate, mobile money accounts registered in sub-Saharan Africa account for more than half of all mobile money written reports around the globe. The urban–rural and gender divides, low digital literacy, and a lack of connectivity and energy are just a few of the real-life obstacles many people in the region experience today when trying to receive digital healthcare.

Figure 2.2 Digital health solutions and treatments, the populations they aim to serve, and their effects on health outcomes must enable and limit factors.



Digital health solutions and treatments, the populations they aim to serve, and their effects on health outcomes all have to enable and limit factors—source: Lancet Digital Health.

Digital health technologies and therapies are being used in sub-Saharan Africa's youthful population to improve their health and well-being, according to our dialogue. Digital health may thrive in Sub-Saharan Africa, but it needs local demand, national government support, and backing from major global organizations like the UN and the WHO. Increasing digital health activities in the region requires addressing individual barriers, such as a lack of computer literacy and connectivity. The lessons learned in Sub-Saharan Africa may be helpful to partners in the global north, which are increasingly utilizing opportunities for reverse innovation, even if this is true. The continent has emerged as an attractive partner for collaboration in developing digital innovation.

2.3.5 Governance and organizational infrastructure

The emergence of global health governance has made it possible to provide health care outside of national borders. Health issues worldwide have become increasingly intricate and interconnected due to growing interdependence and global connection.

Foreign aid and financial pledges from African governments have not improved the health results in Sub-Saharan Africa (Mooketsane & Phirinyane, 2015).

Our healthcare and procurement systems, on the other hand, are rife with corruption. Decentralization of Ghana's health care system, which has been underway since the 1980s, is far from complete, despite the country's efforts to do so. Nevertheless, Ghana's development has already made decentralized health care a reality. However, a long way before decentralization will be considered a success.

Ghana has laid the groundwork for a completely decentralized healthcare system throughout the years. However, there is no complete legal and regulatory framework for the health sector, conflicts, and duplications from successive waves of legislation, and an inability to administer a decentralized healthcare system.

Additionally, political instability and a lack of consistency in the process have hampered it, resulting in the current disarray in the healthcare system (Couttolenc, 2012).

In recent decades, the healthcare business has seen much change. Then, MoH was the sole supplier of services, with aid from missions and para-governmental groups such as the military and police. Instead of focusing on illness prevention, its services tended to be more therapeutic.

Act 525, which established the Ghana Health Service as a public health agency, was passed into law in Ghana in 1996. (GHS). Service provision, policy formulation, and regulatory oversight are now the exclusive domain of the MoH. Due to this vote, the Traditional Medicine Board, the Medical and Dental Councils, the Nurses and Midwives Council, and the Funeral Homes Board benefited from the legislation.

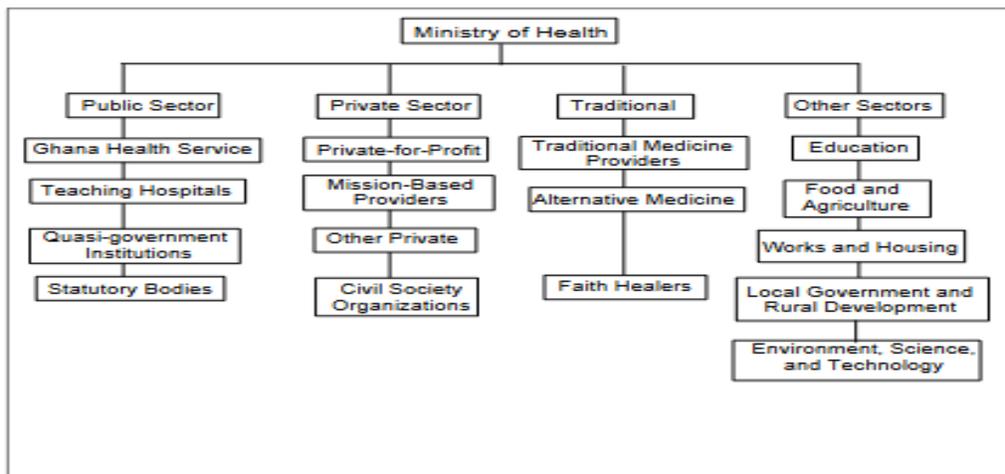
To serve as a fulcrum for federal policymaking, resource mobilization, monitoring, and assessment, the MoH has undergone significant reforms since Act 525 in 2011.

In February of that year, Ghana officially became the first country to establish a healthcare system. The government retains administrative control, but the government no longer employs the GHS, which allows for more managerial latitude. According to MoH ministers, there are several facets of the health care system in the country that need addressing. Ministers at the Ministry of Health (MoH) recognize that the country's health care system is complex. As a

result, public sector services are to be improved, and private practitioners' contributions increased as part of the Ministry's plans.

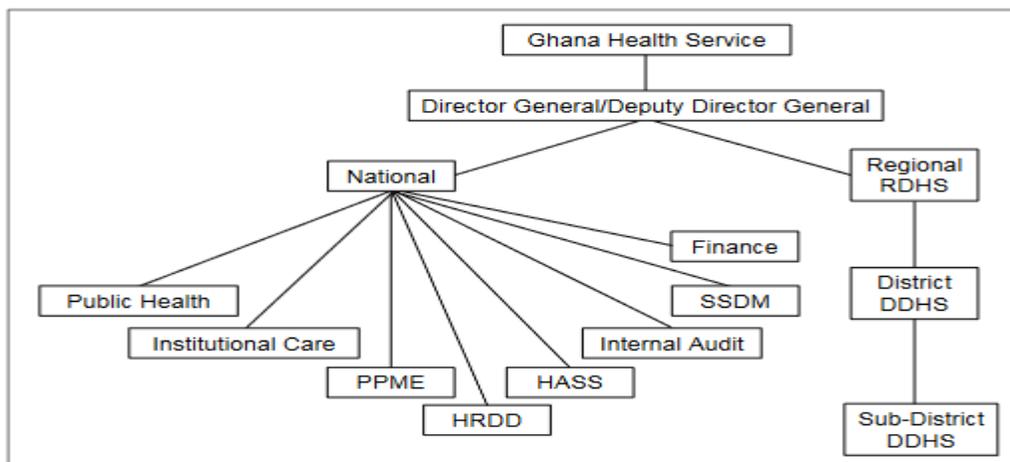
The health sector includes government, commercial, traditional, and non-governmental health care providers; civil society; and community groups.

Figure 2.3 Ministry of Health's ties to Ghana's numerous industries and organizations.



Ministry of Health's ties to Ghana's numerous industries and organizations. Source: Unknown

Figure 2.4 The Ghana Health Service has several divisions.



The Ghana Health Service has several divisions. Source: Unknown

2.3.5.1 Health Facilities

There is a table showing the distribution of health facilities based on kind and location.

2.3.5.2 Health Centres

Most people's first point of contact regarding health care is their local health facility. Some medical assistants have midwifery, nutrition, environmental health, and public health backgrounds. Each of the health clinics serves an average of 20,000 people. Primary health care for adults and children is available in addition to services addressing reproduction and sexual health issues. Incision and drainage, for example, are commonplace in these treatments. Additionally, they offer outreach services and direct referrals for more severe and complicated ailments to better assist their customers. "Polyclinics" are given to health care facilities in rural places.

It is common for polyclinics to be larger, offer a more comprehensive range of services, hire doctors, and execute more difficult surgical operations. Most of them are in metropolitan settings.

2.3.5.3 District Hospitals

Depending on the location of the hospital, each area has its clinic. The population served by a district hospital ranges typically from 100,000 to 200,000. The hospital serves as an essential connection in the command chain and is the principal medical institution in the area.

2.3.5.4 Regional Hospitals

Regional hospitals provide secondary health care to their local communities. This agency serves around 1.2 million individuals. For the regional health system to function appropriately, regional hospitals must. A district hospital will send patients to them if they need specialist care requiring knowledge and expertise not available at the district hospital level. They should include medical professionals on their team, including general surgeons, general practitioners, pediatricians, general and specialist nurses, and midwives. Regional hospitals should have at least 150 to 200 beds.

2.3.5.5 Teaching Hospitals

Teaching hospitals are vital because they provide patients with high-quality care. As a result of their high public and political visibility, teaching hospitals have a unique form of administration that involves various parties, from the health and education ministries to local universities and political parties. These facilities, to be adequate, require cutting-edge technology and a highly skilled workforce. They have a small pool of available resources and keeping them running is expensive. In addition, they aid in training healthcare workers before and after they enter the workforce.

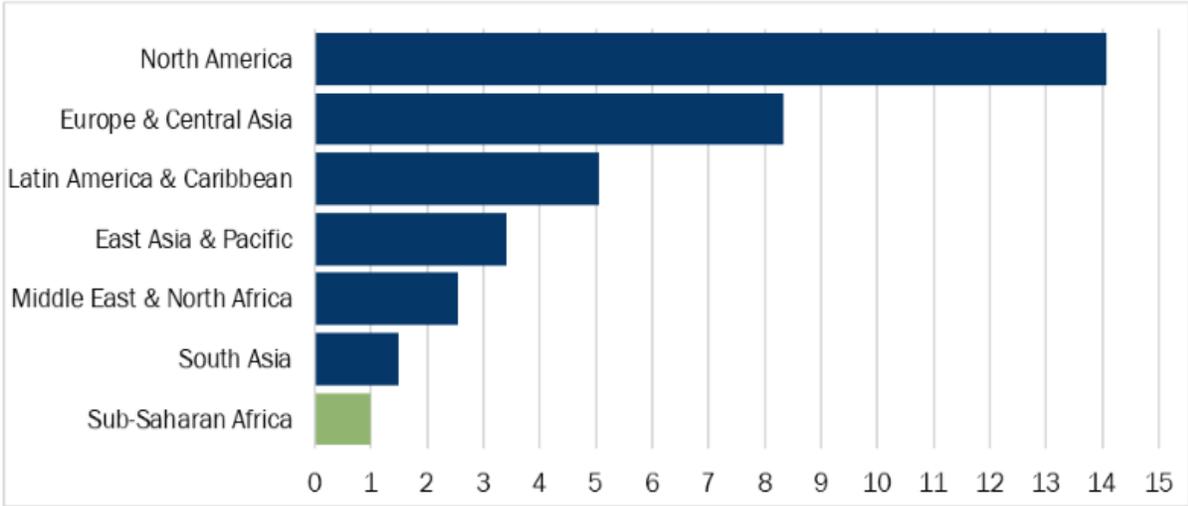
2.3.6 Staff structures

The healthcare business in Africa suffers from a supply and demand imbalance and poor facility management due to a shortage of well-trained medical workers. As a result, there will be a 45 percent increase in the number of health professionals needed in Africa by 2030, according to the World Health Organization (WHO).

More than 20 African countries have less than one physician for every 10,000 people. The sub-Saharan African area has the lowest physician-to-population ratio globally, with just 2.1 physicians for every 10,000 people (less than 12 percent of the global average). In Sub-Saharan Africa, the average number of nurses and midwives per 10,000 residents is 9.94 (less than one-third of the world average), with fewer than five in 12 countries.

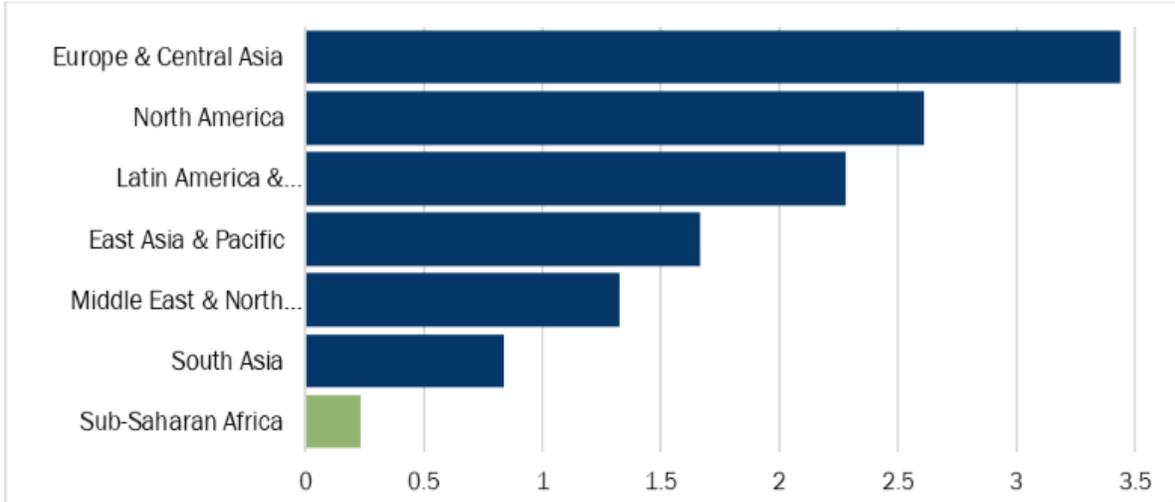
In addition, the medical workforce in most African nations is understaffed relative to the population. According to the Sustainable Development Goals, the average number of health professionals per 1,000 inhabitants in Africa was 1.3 in 2015. ²⁹ There is also a medical "brain drain" that threatens several African countries, resulting in a shortage of qualified healthcare workers.

Figure 2.5 Nurses and Midwives per 1,000 people in 2018



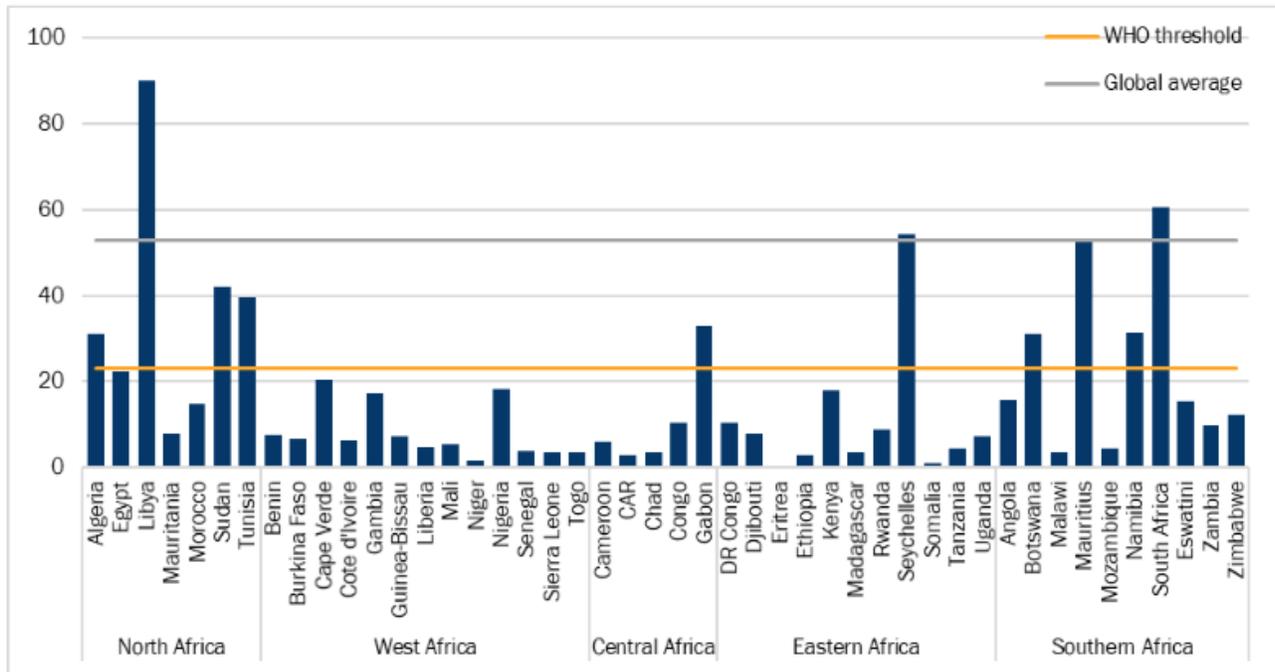
Source: World Health Organization, extracted from African Growth Initiative at Brookings

Figure 2.6 Physicians per 1,000 people in 2017



Source: World Health Organization, extracted from African Growth Initiative at Brookings

Figure 2.7 Skilled health professional density per 10,000 by African sub-region, various years.



The lack of qualified health professionals in the sub-region demonstrates Africa's general underperformance and the differences within and among sub-regions. Source: World Health Organization, extracted from African Growth Initiative at Brookings

2.3.6.1 Reversal of nurses' brain drain in Ghana

Because of a scarcity of resources at home, several African countries fund the training of medical professionals and nurses outside of their borders. As a result, a "brain drain" from Africa's health industry occurs as freshly qualified experts leave the continent for better working conditions and excellent compensation elsewhere.

Newly certified nurses in Ghana can now travel overseas to pursue more lucrative work, according to a report by BBC Africa's Sammy Darko on February 27, 2015.

West Africa had a shortage of nurses ten years ago when many left the nation for the West in search of better employment possibilities. However, Ghana's government scrapped an agreement requiring nurses to work for five years in Ghana before leaving.

Because of the policy's success, the government now argues that it has enough nurses and that bonding them is no longer necessary. Health Ministry deputy director Dr. Kwesi Abir told the BBC that more private schools are now churning out nurses, and some cannot even find work.

He argued that nursing tuition and allowances were "pointless" because many students were already paying for private school tuition.

As it takes so long to become a licensed nurse, it is unlikely that the policy change would result in a significant outflow of nurses. As it takes so long to become a licensed nurse, it is unlikely that the policy change would result in a significant outflow of nurses.

There is a penalty of \$650 (£422) for each unfinished year if a nurse wishes to jump the bond, which is something that few can afford. Furthermore, if they do not pay the fee, they will not be able to get a work visa overseas.

Figure 2.8: Nurses who entered the training scheme had to commit to staying in Ghana for five years after qualifying.



Nurses who entered the training scheme had to commit to staying in Ghana for five years after qualifying. Source: BBC

Accra, Ghana's capital, is home to the Korle Bu Teaching Hospital, a site where this sentiment is evident. A large hall filled with pregnant ladies waiting for prenatal treatments has nurses who appear to be under stress as they cater to their patients in the maternity unit.

Poor hospital infrastructure, as reported by nurses questioned by the BBC, hinders high-quality care. Numerous issues are listed, such as a lack of protective plastic gloves, a lack of available beds in hospitals, a scarcity of water and chemicals, and frequent blackouts.

There is an expectation that nurses in Ghana will leave the country as the cost-of-living increases. The National Health Service in the United Kingdom pays a newly trained nurse at least \$2,695 a month, or over \$21,000 a year (NHS). The average monthly salary for a

professional nurse in Ghana is \$400. Aside from waiting months to get paid, nurses have difficulty dealing with the delays.

At this point, the health ministry estimates that just about 300 nurses have left Ghana in the last two years alone. Behind the numbers, there are grave concerns regarding the quality of healthcare services. As a result, children from low-income families will no longer be eligible for the government-funded program.

Officials say the nation will see improvement in hospitals and wait times due to canceling the nurses' training funds.

For this study, the researcher is looking for innovative ways to deploy nurses in Ghana's and Sub-Saharan African public hospitals so that they may lower the high wait times in outpatient departments.

2.3.7 Sustainable healthcare

Despite the many challenges, a critical need exists to study how and under what conditions health programs in Sub-Saharan Africa are sustained.

The World Bank recommended cost recovery in 1987 as part of a strategy for supporting public health care in developing countries. However, many are concerned that the poorest citizens may be denied access to modern healthcare due to user fees in government-run facilities or costly insurance plans (Griffin et al., 1996).

Academic research published in *Implementation Science* focused on a comprehensive assessment and conceptual framework for health treatments implemented in Sub-Saharan Africa.

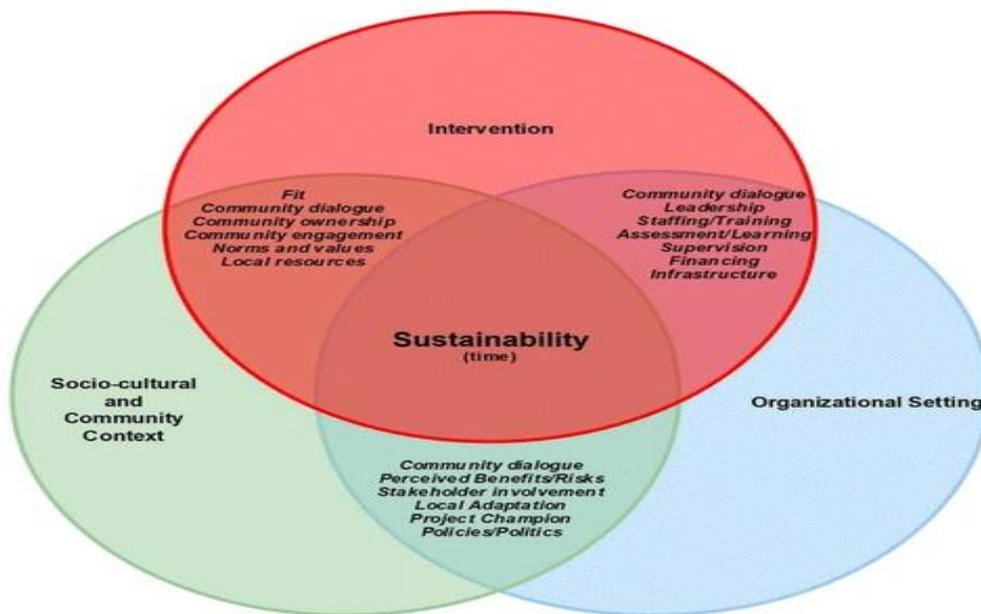
They examined MEDLINE, biological abstracts, CINAHL, Embase, PsycInfo, SCIELO, Web of Science, and Google Scholar to locate research on the sustainability of health treatments implemented in sub-Saharan Africa. As part of this study, they used narrative analysis to look at the factors that might affect the region's long-term success of health efforts.

Most of the available data on sustainability comes from Kenya and Nigeria, two nations represented in this analysis. The investigation lasted almost two decades, from 1996 to 2015. There was 30 percent of these studies published in 2014, which is noteworthy. In at least four of the studies, they employed a sustainability framework. HIV/AIDS and malaria were the second and third most studied long-term impacts. Although community ownership and mobilization were significant intervention facilitators for sustainability in many analyzed studies, social and ecological issues and societal upheavals were hurdles that hindered interventions in sub-Saharan Africa, according to the findings (SSA).

The researchers developed a comprehensive conceptual framework to map the terrain of findings from interventions carried out in SSA, emphasizing sustainability and combining elements of frameworks such as DSF with health frameworks already in place in the area, such as the PEN-3 cultural model. According to the investigators.

The image below shows organizational qualities and an intervention's ability to interact with the larger socio-cultural and communal context. Every intervention is made more effective by emphasizing long-term sustainability.

Figure 2.9: Conceptual framework of sustainability of interventions implemented in SSA.



Conceptual framework of sustainability of interventions implemented in SSA. Source: Implementation Science

According to scholars, health treatments in sub-Saharan Africa will have to be sustainable because of the high sickness load, a lack of healthcare personnel, poor healthcare institutions, and limited finances. Therefore, there was an emphasis on long-term viability in their conceptual framework.

Studying how these connections overlap over time is essential to the region's health intervention sustainability research. The researchers recommended integrated approaches for long-term sustainability programs due to the region's limited resources and the expanding dual burden of illness in SSA (Iwelunmor et al., 2016).

2.4 Case Studies

2.4.1 Outpatient Workflow Automation at Oregon Medical Group (Case Study 1)



Figure 2.10: Automation through RTLS can transform patient care. Source: healthcare facilities today

2.4.1.1 Situation

In 2018, Oregon Medical Group began planning for the opening of its 46,000-square-foot outpatient facility in Eugene. Unfortunately, all patients were obliged to check in at a single registration room on the first floor of the new facility, which was separate from the organization's 16 other clinics in the area. As a result, people must be personally escorted out of waiting rooms and informed of the length of time they may anticipate being there.

Hospital departments must be aware of patients' status and whereabouts to distribute resources effectively. Unfortunately, the new building's floor arrangement also did not permit the

conventional medical flag system, which Oregon Medical Group's several clinics previously employed.

2.4.1.2 Solution

Oregon Medical Group employed real-time location system (RTLS) technology to solve the organization's workflow issues. They formed a joint venture to integrate CenTrak's asset monitoring software with its current patient and employee location tracking system. The selection was due to its room-specific location precision.

Patient registration efficiency increased with the RTLS system's data connection with Oregon Medical Group's EHR system. In addition, patients could spend more time with their healthcare providers because of reduced wait times.

2.4.1.3 Benefits

RFID, making it a valuable tool for everyone at Oregon Medical Group. For example, clinical teams could use this data to improve treatment quality and the overall patient experience to identify bottlenecks in the workflow.

According to Steve Liu, CenTrak's Director of IT, its RTLS system has enormously influenced efficiency. Patients are spending more time with their healthcare professionals, which has resulted in shorter wait times for appointments. Since these discoveries, both patient and provider satisfaction has gone up.

2.4.1.4 Conclusion

CenTrak healthcare workflow solutions cut patient wait times by 75% while increasing care time by 50%. To make patient self-rooming viable, a bespoke RTLS system developed by active Oregon Medical Group has replaced the standard waiting room with one that allows patients to register at the front desk and proceed straight to their exam rooms. Waiting patients are alerted when they enter an exam room and are ready to be examined.

Patient self-grooming, made possible by RTLS technology, has improved care provider satisfaction rates by saving clinicians up to 90 minutes per day in travel between waiting areas and exam rooms. Customer happiness, lower expenses, reduced burdens on staff members, and more reliable customer service are all objectives of job automation.

2.4.2 laboratory case study: the hospital's most critical department? (Case Study 2)



Figure 2.11: Lab Automation. Source - luchschenF/Shutterstock.com

2.4.2.1 Situation

Dr. Kenneth E. Blick, Professor and Director of Chemistry and Lab Automation at Oklahoma Health Sciences Center's Department of Pathology, says that 70–80 percent of a patient's medical record is laboratory data. As a result, medical practice is shifting toward a more evidence-based approach (at least in the US), and we should examine the role and impact of laboratory services on patient care.

Researchers from Texas and Oklahoma who studied 12 hospitals found that the laboratory directly influenced the flow of patients through the emergency room (A&E). According to these two studies, patients' A&E length-of-stay (LOS) can be affected by poorly operated laboratories providing an "unpredictable service," which can delay critical clinical decisions in A&E and other hospital departments where patients need life-saving medical treatment.

On the other hand, in 2003, the medical staff at the University of Oklahoma Medical Center (OUMC) tracked the number of times their potassium turnaround time (TAT) of 40 minutes was missed when administering the medication to A&E patients. Just 17% of the time did they meet the claimed TAT of 40 minutes. Their "normal" potassium tests, on the other hand, take anything from 40 to 150 minutes to complete. Responded to this unpredictability by physicians and nurses at all three teaching hospitals: minute TAT target 18% of the time. On the other hand, their "routine" potassium tests took 40–150 minutes. Physicians and nurses throughout the three teaching hospitals responded to this unpredictable service by:

1. They are frequently calling the laboratory asking for verbal reports.
2. Ordering tests as Stat requests.

3. They lack general support for the laboratory service. The OUMC's TAT orders have increased by nearly 53%, and 1.5 full-time equivalents are needed to answer the phone.

2.4.2.2 Solution

In 2003, the OUMC laboratory embarked on a quest to remove the need for TAT testing by utilizing cutting-edge computer systems and robotics. An automated testing method was essential for every stage of this process, from arranging an exam to having samples collected and delivered to a lab to processing and transmitting findings online and in real-time. There were two types of laboratory tests performed simultaneously:

1. Total laboratory automation (TLA) systems are commercially available and may be used to automate a central core laboratory.
2. When testing in the automated core laboratory was not enough to address crucial patient care demands, complete automation of point-of-care (POC) testing was required.

2.4.2.3 Benefits

Outlier percentages for potassium (and other chemistry exams) have dropped from 18% to less than 3% in the past nine months. All specimens were tested in real time to prevent the need for Stat testing. After 1.5 years, physician requests for Stat testing decreased from 53% to fewer than 4%, indicating that the latter are actual clinical events. This study's authors, "dissatisfaction with the preceding nonautomated, batch-testing approach to laboratory medicine

is no more." In addition, because of fewer physician and nurse phone calls, the laboratory staff may now devote their attention to testing and other quality improvement initiatives.

Before automation, non-admitted A&E patients had an A&E LOS of 18 percent ($r^2 = 0.95$) and a TAT OP of 18 percent. However, before they deleted TAT outliers, the correlation between TAT OP for potassium and A&E patient LOS became statistically negligible, with a $r^2 = 0.54$. This discovery allowed them to rule out the laboratory's involvement in A&E LOS.

2.4.2.4 Conclusion

If a hospital wants a "real-time" patient flow, it should remove the racks of samples sitting in the laboratory. In the A&E and other hospital departments, a frame of specimens awaiting analysis in the lab is undoubtedly equivalent to a patient's rack (or line). Real-time data may be collected in the lab using TLA, robots, expert computers, biosensors, immunological sensors, and automated walk-away analyzers.

Diagnostic labs are under pressure because of an aging population, rising testing demand, and a high staff turnover. Lab automation reduces worker stress, boosts productivity, and improves quality. The whole OUMC;

- Save staff time for more engaging work.
- Increases efficiency in the lab.
- Removed human error and enabled more reproducible consistent results.
- It improved lab safety by reducing the risk of repetitive strain injuries.

2.4.3 An Automation Solution for Rural Outpatient Pharmacy Services (Case Study 3)



Figure 2.12: Pharmacy automation. Source - Chester County Hospital

2.4.3.1 Situation

314-bed The Sisters of Charity of Leavenworth Health System in Billings, Montana, includes St. Vincent Healthcare. The hospital distributes over 5,600 doses each day and manages over 1,700 prescriptions from doctors. Located in Harlowton, Montana, Wheatland Memorial Hospital is a 25-bed critical access hospital run by St. Vincent Healthcare. Harlowton is a town of 900 inhabitants in a county of 2,400, with a population density of only 1.6 persons per square mile.

In May of 2003, the Harlowton retail pharmacy closed its doors. A 45-mile distance from Wheatland Memorial meant the pharmacy was out of reach for its residents. The clinic at Wheatland Memorial lost 17% of its patient base due to its closure. An individual patient said,

"If I go that far for medication, why not see a doctor nearby?" As a result, Wheatland Memorial's board of directors prioritized addressing the absence of outpatient or retail pharmacy services in the area. As a short-term solution, St. Vincent's provided Wheatland Memorial with pre-packaged and pre-labeled prescriptions for 23 different urgent medications. As a result, the hospital developed an alternative plan of action.

2.4.3.2 Solution

The selection of tele pharmacy solutions provided by AmerisourceBergen Technology Group was due to a comprehensive evaluation of the alternatives. Three bar code checks successfully utilized this ground-breaking technology to certify that the proper medication to the correct patient was a success. In addition, patients can speak with their pharmacy staff through video phone at St. Vincent's Hospital in New York City's Tele pharmacy. They were thrilled to learn that the Internet connection between St. Vincent and Wheatland Memorial will support the Tele pharmacy system. As part of their purchase evaluation, they worked closely with their state's board of pharmacy to verify compliance with all applicable regulations. Following the state board's approval, pharmacists and doctors could get two significant grants to fund the acquisition of a new technique.

That included a separate license for the Wheatland Memorial outpatient pharmacy information system, a videophone system, and two Tele pharmacy Solutions. It is like a candy vending machine at Wheatland Memorial, with biometric-enabled cabinets that can hold 80-line items. St. Vincent Pharmacy uses standard plastic bottles to package medications for the Tele pharmacy cabinets. Each bottle has a label with the drug's name, strength, dosage, lot number, and expiration date.

The new approach allows prescriptions to be written at Wheatland Memorial and forwarded to St. Vincent's pharmacy. A St. Vincent's pharmacist can enter orders into outpatient pharmacy information systems and check them for allergies, drug interactions, and other issues using Tele pharmacy-networked workstations. Third-party adjudication determines a patient's insurance coverage and cost once the pharmacist prints a sample prescription label. When the Tele pharmacy information system completes these steps, it notifies the Wheatland Memorial pharmacy technician that a prescription is ready for dispensing. When a technician selects a patient's name from a touch-screen computer, a cabinet full of pre-packaged drugs is issued.

To ensure that the bar code on the bottle matches the bar code on the patient's prescription, they consult a pharmacist at St. Vincent's. Afterward, the pharmacist verifies the payment of the patient's cost. Pharmacists can also utilize a videophone to confirm the issuance of prescriptions and label accurately, then meet with a patient in a private area to discuss their concerns.

2.4.3.3 Benefits

Tele pharmacy systems like this have made it easier for people living in the community to acquire the necessary pharmaceutical therapy. In addition, St. Vincent's pharmacists are more involved with their patients as an additional advantage to their profession. Patients may get a prescription and be on their way in as little as ten minutes at the pharmacy at Wheatland Memorial.

According to a recent poll, the Tele pharmacy service received a rating of 4.68 out of 5. Because it keeps businesses in Harlowton rather than sending them elsewhere, the hospitals have no immediate bottom-line gains, but the local economy benefits from the initiative.

2.4.3.4 Conclusion

Every day, they file 14 prescriptions using Tele pharmacy. That has allowed them to give patients in Harlowton couriered medications at set pricing, taking advantage of the system. In addition, several Montana hospitals are exploring employing Tele pharmacy to provide after-hours pharmacy treatment following the success of one of their member hospitals. They were happy to be a resource for other institutions thinking about using the system and jumped at the chance.

In response to the program's success, Tele pharmacy was awarded an innovation award by the Montana Health Association and a comparable award by the Montana Pharmacists Association.

However cutting-edge the Tele pharmacy system may be, it works because of the people who work on it; they all want to make it easier for patients in the Harlowton area to acquire their medication. Client-centeredness is essential to true innovation. Great things happen when the customer is at the center of all decisions.

Chapter 3: Operational Framework

3.1 WHO and UNICEF Framework

World Health Organization (WHO) as well as United Nations International Children's Emergency Fund (UNICEF) created the Operational Framework for Primary HealthCare.

"Develop an operational framework for primary healthcare to be fully taken into account in the WHO general programs of work and program budgets to strengthen health systems and to consult with and involve more expertise from the Member States" is one of the many things WHA72.2 asks of the Director-General. The World Health Assembly's 73rd session, held in 2019, considered this subject (WHO & UNICEF, 2020).

As a result of wide-ranging literature analysis, national case studies, and participation from an advisory committee, the operational framework for primary healthcare in this century has been developed with a vision for 21st-century primary health care and supporting technical documentation.

The Alma-Ata Declaration served as a foundation for the Astana Declaration, endorsed during the Global Conference on Primary Healthcare in Astana on October 25 and 26, 2018. Developing sustainable health systems for universal health coverage and the Sustainable Development Goals related to this area were reaffirmed in the Astana Declaration by the Member States. Two earlier resolutions, WHA69.24 (2016) on improving integrated, people-centered health services and WHA65.8 (2012) on national policies, strategies, and plans, attempted to reinforce the Alma-Ata declaration's aims of primary health care.

Figure 3.1: Primary healthcare components. Source - WHO



Fourteen levers are provided in the operational framework (see Table 1) for implementing the global commitments indicated in the Astana Declaration. People of all socioeconomic backgrounds may benefit from these efforts and initiatives to strengthen primary healthcare-oriented systems.

Table 3.1. Overview of Primary healthcare levers. Sources - WHO

| Title | Full Description |
|-------------------------------------|---|
| Core strategic levers | |
| Political commitment and leadership | Support for the SDGs places PHC at the center of efforts to attain universal health coverage and recognizes it as a significant contributor. |
| Governance and policy frameworks | With support for the SDGs, primary health care (PHC) is at the center of efforts to get everyone covered by health insurance as a significant contributor. In addition, PHC governance structures, policy |

| | |
|--|---|
| | frameworks, and laws help different sectors and sectors within a community work together and hold each other accountable. |
| Funding and allocation of resources | Inadequate funds for primary health care that can be organized and distributed for fairness in access offer a platform and an incentive to enable high-quality health services while minimizing financial burden. |
| Engagement of community and other stakeholders | participation of communities and other interested parties from various fields to identify issues and potential solutions, as well as to set priorities for future action. |
| Operational Levers | |
| Models of care | Integrated health services build on a foundation of patient-centered primary care and essential public health duties. |
| Primary health care workforce | It is vital to have a primary health care staff of the facility, outreach, and community-based health experts, all supported by good management oversight and fair pay. |
| Physical infrastructure | Accessible and safe healthcare facilities with reliable water and sewage systems, waste disposal and recycling, telecommunications and power sources, and transportation networks that connect patients to other health care providers are crucial for providing quality treatment. |
| Medicines and other health products | To promote good health, safe, effective, high-quality drugs and other health care supplies must be available through open, accountable systems. |
| Engagement with private sector providers | Public-private collaboration is essential to providing comprehensive health care. |
| Purchasing and payment systems | Purchasing and payment methods for healthcare that encourage the use of primary care and public health rather than fragmented, walled delivery models |
| Digital technologies for health | Using digital technology in health care could make it easier for people to get care and services and make care more efficient and accountable. |
| Systems for improving the quality of care | Integrated health care must be constantly examined and improved at the municipal, subnational, and national levels. |
| Primary healthcare-oriented research | As part of the research and management of knowledge, this means spreading the lessons learned from successful PHC-focused systems and expanding successful projects. |
| Monitoring and evaluation | A sound health information system is needed to help people make better decisions and learn more at the local, national, and global levels. |

An intervention that affects one lever will ripple effect on other levers and allow more actions. Therefore, we need a plan that prioritizes and prioritizes all three parts of universal healthcare as part of our national health care strategy (WHO & UNICEF, 2020).

As a partner nation, there must be adherence to the WHO framework. The researcher believes that health-related digital technologies can play an essential role in achieving the desired

outcome. Because of this, the researcher chose to use this thesis to aid countries' public healthcare organizations execute these WHO and UNICEF guidelines using digital technology as a focal point.

It was on December 20, 2021, that Emmanuel Kumah and his colleagues published "Framework for analyzing the Ghanaian health system" in Health Research Policy and Systems.

According to the group's results, health systems may improve by employing quantitative and qualitative methodologies to evaluate their efficacy. However, although health system performance assessment (HSPA) has become integral to many high-income countries' health systems, little study has been done in low- and middle-income countries, including Ghana.

Their research aims to establish a comprehensive framework for periodic reviews of the Ghanaian health care system. Therefore, the WHO and UNICEF operational framework for primary health care in Sub-Saharan Africa are appropriate.

That supports the idea that a solid conceptual framework within which performance measures may be examined and applied regularly are essential prerequisites for every nation's performance measurement system. The structure they are working on will encompass all of Ghana's vital healthcare components.

Our goal is to ensure that the framework is consistent with Ghana's health system objectives, relates to information technology (IT) and regular data collection in the nation, comprises high priority and problematic areas, and has globally comparable measurement indicators. (Kumah et al., 2021).

3.2 Public Healthcare Delivery: Ghana's Case

Ghana's healthcare system's three levels of governance are the national, regional, and district systems. In addition, there are several clinics and hospitals where patients can receive various healthcare degrees.

There is a wide range of medical care in Ghana, depending on where one lives. As a result, most of the country's hospitals, clinics, and pharmacies are in metropolitan areas. However, modern healthcare may not be available in rural areas. They either rely on African medicine for therapy or go a long way. The Ghana Health Service (GHS) and the Ministry of Health (MoH) are largely responsible for running and funding Ghana's healthcare system. There are five types of providers in the healthcare system: health centers and clinics, district and regional hospitals, and tertiary hospitals. Internally Generated Funds, Ghana's government, and Donors-Pooled Health Fund provide the funds.

3.2.1 Prospects

Ghana produces only a tiny proportion of the medications, medical gadgets, and electronics Clients like. That has resulted in an 85 percent dependence on imported healthcare. In addition, all medical expenditures in Ghana are no longer paid for by the patient, as there is no longer a "pay as you go" system. Currently, the National Health Insurance Scheme covers the most prevalent ailments, including malaria. Nevertheless, on the other hand, the plan only covers a limited range of illnesses.

Private healthcare facilities exist in addition to public ones. In Ghana, efforts have expanded private sector participation in the healthcare sector. Private hospitals, clinics, and the

pharmaceutical business will have the most rapid growth and exciting potential in the following years. Clients favor private facilities because of their high quality and convenience. A growing middle class is eager and able to pay for private health care options. The following areas provide commercial possibilities:

A wide range of healthcare facilities and services include the construction of hospitals and clinics, including diagnostic and laboratory facilities (histopathology), drug procurement and supply management, medical equipment, digital hospital equipment, ICT hospital management, hospital waste management, advanced laboratory equipment, advanced life support, and monitoring systems.

Additionally, other possibilities deserve consideration:

1. Health insurance coverage for the public healthcare system is for the aged, people with disabilities, and those who dwell in residential care institutions.
2. Air ambulance and first aid services

The following services are available:

1. Medical equipment repair and maintenance services
2. X-ray, MRI, and CT scan diagnostics
3. Histopathology and other sophisticated laboratory diagnostics
4. Maintenance and repair services for medical equipment
5. Mortuary services

3.2.2 Challenges

When managing hospital-based public health activities and liaising with other Health Directorates, Public Health Units (PHUs) play an essential role. Health evaluations, hospital recommendations, and excellent treatment depend on a well-functioning public health unit. However, some of Ghana's health system issues are limited healthcare facilities and a lack of medical professionals.

3.3 Functional Analysis

Table 3.2: Shows an A3 Report and a Functional Analysis of public healthcare delivery in Sub-Saharan Africa. Source - Researcher

| Problem definition | Desired condition |
|--|--|
| To get a patient's medical data, authorities at our government hospital must first request a hospital card from the patient. Then, a first-in-first-out (FIFO) approach allows the folders to enter the consultation room. Since there are many patients in public hospitals, it takes four hours for them to go through the record, consultation, laboratory, and pharmacy cycle at the public hospitals. On the other hand, patients at private hospitals have to wait 30 minutes to an hour for | <ol style="list-style-type: none"><li data-bbox="889 1138 1409 1528">1. Create an intelligent OPD that will employ a few Doctors to sit by a central console to provide General care to patients. The doctors can also use the web and mobile apps to deliver their services.<li data-bbox="889 1570 1432 1738">2. A GPRS system will lead registered nurses on the platform to attend to patients at their homes or offices. |

| | |
|--|---|
| <p>the same experience. Because of the high volume of patients that attend the government outpatient department each day, it has become almost impossible for the medical staff to provide high-quality treatment. As a result of lengthy waits at public health facilities, patients, and healthcare providers alike encounter difficulties.</p> | <ol style="list-style-type: none"> 3. Specimen delivered to the lab without the patient moving 4. A prescribed drug will be dispensed and delivered to the patient as they walk to the nearest pharmacy shop or by dispatch service. 5. Staff can sit in the office and receive medical care without spending hours in the OPD, which is a massive cost to the government and the employers. |
| <p>Background of the problem</p> <p>In today's healthcare system, there is an abundance of holdups. As a result, timeliness was designated as one of six main goals for development in 2001 by the Institute of Medicine (IOM), the leading advisory organization for government and the commercial sector on health-related problems.</p> <p>"Timeliness" is one of six "aims for improvement" listed by the Institute of Medicine in its most current report on quality.</p> <p>Nevertheless, patients' discontent and worsening health outcomes are some of the results of delays in care (Green, 2008).</p> | <p>Recommendations</p> <p>CNN Business' Nell Lewis reports that the World Bank says Sub-Saharan Africa has the world's poorest healthcare on average. Only 3% of the world's health workers and 1% of the global health budget are combating this condition, responsible for a quarter of all disease-related disabilities and death (Lewis, 2019).</p> |

| | |
|--|---|
| <p>Many people have difficulty accessing affordable and high-quality primary and urgent health care services, and many sick children and adults do not receive the proper medical attention they require.</p> <p>Overcrowding is associated with poor patient outcomes, staff burnout, discontent, nosocomial infections, mortality, poor patient outcomes, increased medical errors, and reduced patient safety (Bahadori et al., 2017).</p> <p>Long delays at the hospital have impacted many families and social network members. Many people complained about long waits at hospitals and missed appointments with doctors. In addition, while waiting in line due to poor queue management, someone else may be allowed, and so on.</p> | <p>The 1% health budget accounts for inadequate infrastructure, which amounts to few facilities in the capital cities and limited health posts in the rural areas, accounting for long queues at the public healthcare in the country.</p> <p>There is a need for the governments in Sub-Saharan Africa to invest in technology to enhance and speed-up the delivery of healthcare.</p> |
|--|---|

Root causes

1. Why did this occur?
 - Too many people are visiting the hospital. Is this the root cause? No.
2. If no, why did this occur?
 - Few Doctors were assigned. Is this the root cause? No.
3. If no, why did this occur?
 - Low Doctors are passing out of medical school. Is this the root cause? No.
4. If no, why did this occur?
 - Brain drains. Is this the root cause? No.
5. If no, why did this occur?
 - Public healthcare has limited infrastructure. Is this the root cause? Yes.

Root cause:

Public healthcare has limited infrastructure.

These problems can be alleviated by creating and expanding healthcare facilities, providing financial incentives to healthcare professionals, applying predictive, preventative, and personalized medicine (PPPM) in treatment, and modifying insurance policies for marginalized groups. Furthermore, there should be an emphasis on disease diagnosis and prevention, the improvement of the healthcare system, and the tracking of the diseases and the circumstances that raise one's likelihood of catching them.

Improving screening systems, promoting healthy lifestyles, and educating the public are crucial to resolving healthcare challenges. Enhance rural healthcare workers, decrease death rates, and conduct vaccination and immunization programs. In addition, it increases the number of nurses, physicians, and other healthcare professionals. In order to better serve patients, educate the public, and grow its workforce, the healthcare business has used several strategies.

3.3.1 Operational Processes

A public hospital's outpatient clinic focuses on this sub-topic—a well-known public hospital located in Accra's Ga-West District, Ghana. The result is a significant wait for patients to use the hospital's services. However, the hospital is more accessible to low-income people because of the reduced cost of admission. In addition, patients from all walks of life may use the hospital's top-notch medical care and services.

In addition to service prices and the quality of treatment delivered, responding time is a significant component of total service quality that influences patient satisfaction. People are becoming increasingly vocal about their displeasure with the long wait times for medical care and other services at the outpatient clinic. According to preliminary evidence, patients in private hospitals are likely to have reduced wait times for medical and other services. In this situation,

the coexistence of public and private hospitals poses a risk. Most patients are willing to pay a greater charge to expedite the appointment procedure. This inquiry aims to determine why the procedure takes so long at each stage.

Studying current and standard operating procedures is essential to understanding how outpatient clinic departments operate. The Outpatient Clinic Division (OPD) of the hospital consists of seven clinics.

1. General Practitioners
2. Laboratory of Pathology
3. Obstetrics and Gynecology Clinic
4. Children's Clinic
5. Ear, Nose, and Throat Specialists
6. Surgeons and orthopedics
7. Optometry Offices

Upon arrival at the hospital's registration department (Figure 1), the department will collect the patient's data and send it to the appropriate clinic. The registration staff at the hospital can recommend outpatient clinics to patients judged appropriate or essential. Depending on the severity of a patient's condition, he or she may have to visit more than one clinic throughout a single visit. For example, suppose a patient is through with their treatment. In that case, they are given a prescription and referred to the pharmacy's drug or cashier department, where they can pick up their medication as instructed by the treating physician. After receiving their medication, patients can leave the hospital at any time.

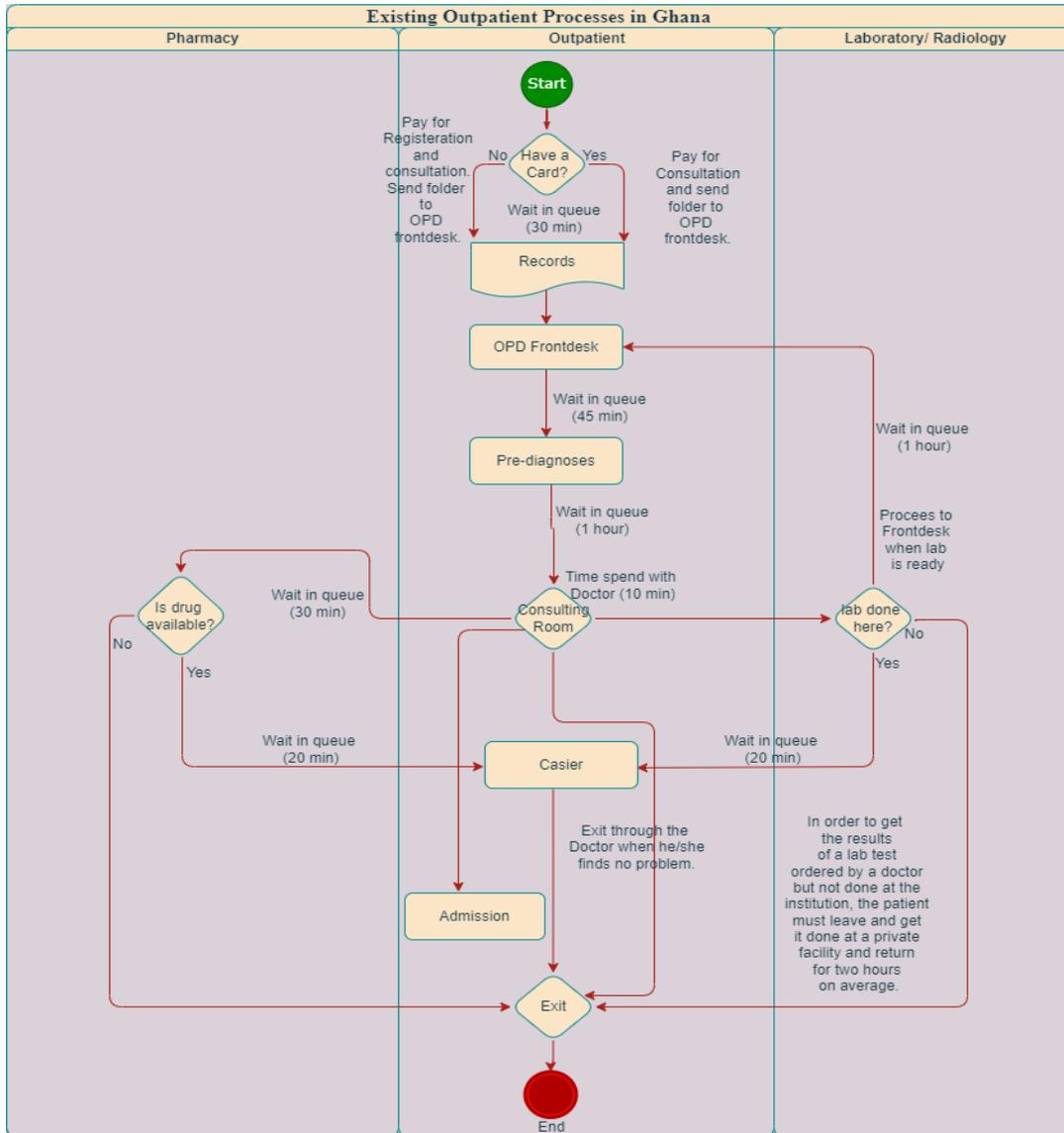
Patients and caregivers must take the ill to private laboratories and pharmacies outside of public healthcare facilities and submit the drugs or lab reports for further medical treatment because most public healthcare facilities lack current laboratory equipment and drugs doctors prescribe. As a result, Sub-Saharan African patients must endure long waits for care.

3.4 Functional Diagrams

The daily number of patients visiting the government OPD has made it difficult for healthcare workers to deliver quality care. To ensure risk-free healthcare for doctors, nurses, and patients in this era of the Covid-19 pandemic, governments in Sub-Saharan Africa need to introduce a system the researcher has named "Smart OPD" to relieve health workers and patients by reducing the number of visits to the hospitals.

The researcher proposes "Smart OPD" as a web and mobile app to deploy a digital health system that will enable patients to receive care from the comfort of their homes or office.

Figure 3.2: Shows the business process of the problem condition



It shows how the lousy state affects the company's operations—credit to the researcher.

At each outpatient session, the time patients spend with their doctor is much less than waiting in line. However, because the number of patients at each outpatient clinic at any given time can significantly impact wait times, it is crucial to bear this in mind when visiting the hospital.

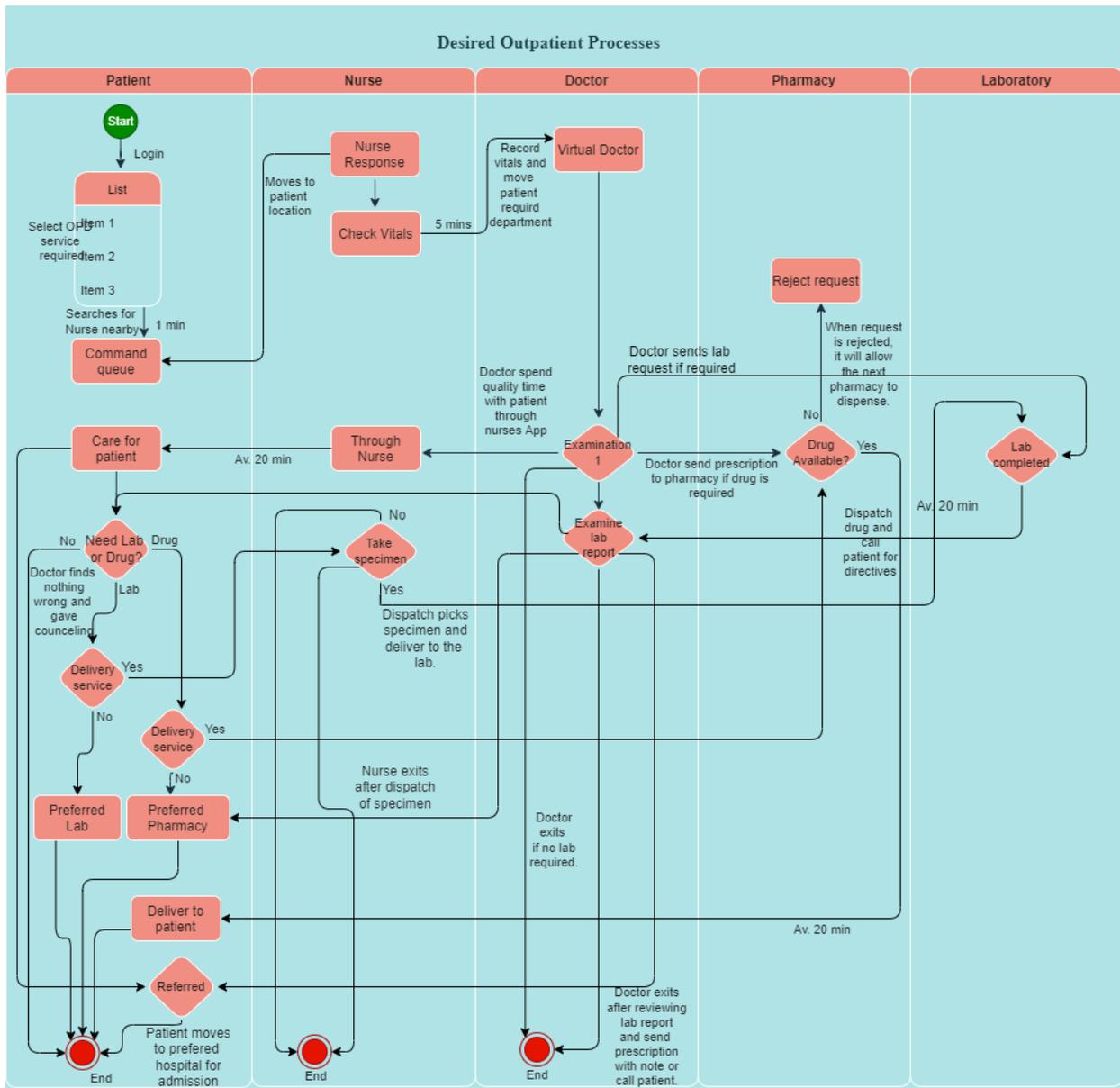
There is a three-hour minimum wait period in most patient clinics to get medical treatment and other hospital services. However, some clinics have more wait times for patients due to a lack of laboratory and radiological facilities, despite their internal operations being the same. To categorize the problem and potential areas for improvement, consider the following three broad categories:

1. **An insufficient number of doctors** - An on-site inspection found many patients gathered outside the doctor's office. That is the main bottleneck in the process. Unfortunately, due to a lack of doctors to handle the influx of patients, the quality of medical care will continue to deteriorate unless addressed by quick actions.
2. **Long waiting time at the laboratory** - After acquiring a prescription from the doctor, patients proceed to the laboratory. Long wait times result from a scarcity of lab employees and appropriate equipment. Referrals occur when a lab does not have the requisite equipment to provide the desired service. ' Outside or private labs, where patients from other labs are also queuing, are becoming increasingly popular. As a result, many patients must make a second trip back to their original medical facilities to present their test outcomes to the doctor.

The researcher must develop creative answers to the problem at hand, which is now hurting all public health facilities throughout Sun-Saharan Africa.

The figure below shows the functional diagram of the desired OPD process.

Figure 3.3: Shows the Business process of the desired condition



Illustrates the ideal state's business process. Credit to the researcher

The picture above shows that the average doctor-patient interaction has grown from 10 to 20 minutes. As a result, there will be less congestion in public hospital waiting rooms if even a tiny percentage of patients use this virtual system.

3.4.1 Doctors and Nurses

1. Doctors of all disciplines must work with the Ministry of Health and the Health Agencies at a single console to provide online patients with virtual healthcare.
2. Nursing organizations must allow applicants to register. Nurses who are currently unemployed or searching for part-time work are encouraged to apply. Patients' GPS coordinates will be available to nurses via the app.
3. Online doctors recommend their patients to their preferred public hospital for physical and additional investigations when necessary. The patient prepares and moves to the designated healthcare facility once the doctor triggers a referral.
4. All registered nurses must have access to digital thermometers, blood pressure meters, and glucose meters to join the platform; otherwise, the Health Ministry must provide this equipment as part of the onboarding process.
5. The app will identify the nurse assigned to a patient by name, registration number, phone number, and photo, and the patient will get notified. Additionally, the patient's nurse will have access to all patient information.
6. Patients that need to be closely followed by their doctor can be observed by their nurse, as the system tracks their time upon admittance and pays them accordingly.
7. Patients should be able to describe what is wrong with them via video chats with doctors while the nurses assist. That will enable the doctor to check their eyes, mouths, and troubled parts.
8. The nurse's job is over once the sample is in the lab. When the test results are ready, the doctor gets an alert after sending an advice letter to the patient and a prescription issued

by the doctor to the pharmacy portal. Doctors may also use the app to communicate with their patients.

9. The doctor will contact the patient once the lab results are available. A free call system, a patient's cell phone number, or a video call on the app are options for the doctor.

3.4.2 Laboratories and Pharmacies

In the literature reviews, the researcher observed that governments must partner with the private sector to deliver quality care to their people. The flowchart in figure 3.1 also shows that patients must leave the hospital to access pharmacy, laboratory, and radiology services in private facilities, which contributes significantly to the wait time. It is therefore essential to partner with the private laboratories and pharmacies to ensure the smooth operation of the Smart OPD.

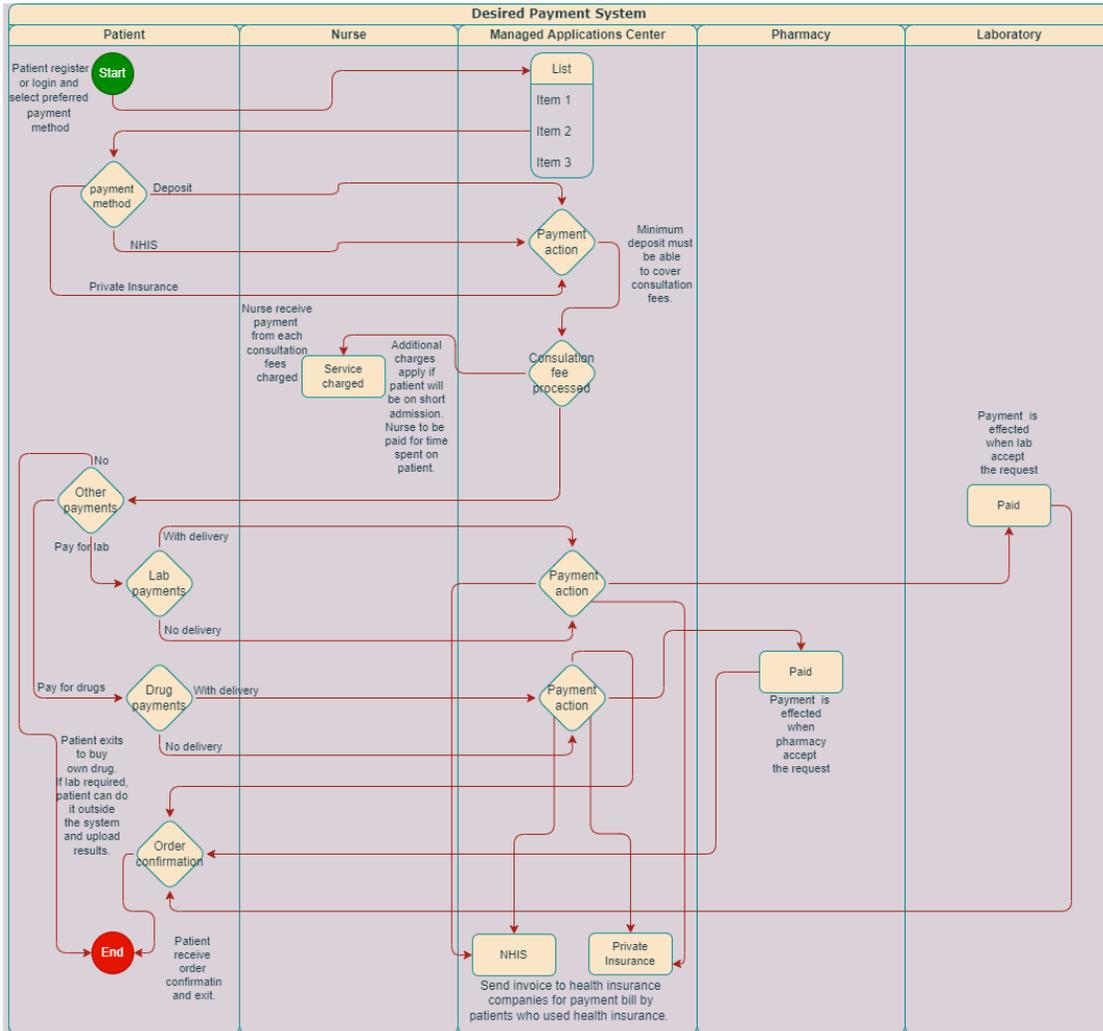
1. Private laboratories and pharmacies must register with the laboratory and pharmacy site to provide virtual service to patients.
2. For a lab to collect a patient's specimen, the nearest registered laboratory must send a dispatch rider. Then, when the patient's GPRS connection gets established, the nurse will guarantee that the sample is available.
3. The attendant updates the system once the lab result is ready, allowing the doctor to proceed with the next step. Again, the doctor receives an alert issued to his or her portal.
4. Patients who use a laboratory or pharmacy's dispatch service will pay a fee. Therefore, patients are encouraged to go to their preferred or nearest accredited laboratory or pharmacy to save money.
5. Patients can see a digital map of all registered laboratories and pharmacies. The app will also recommend a place that is close to the user.

6. The pharmacy closest to the patient receives an alert whenever a patient needs medication and agrees to deliver the drug to the patient. Pharmacies must decline the prescription if they do not have the medicines in stock to allow for a transfer to another pharmacy.
7. Pharmacists should be able to submit patients' dispensing instructions electronically. The message must be accessible at any moment to the patient. In addition, the Pharmacist will get in touch with the patient to go over the dosage and other crucial information. Using the app's video call feature, make a free or a paid call to the patient's mobile phone number.
8. Both the pharmacy and the doctor must be easily accessible to the patient. Upon a doctor's request, patients must be allowed to take vital records and submit information on their mobile devices.

3.4.3 Payment Options

1. Collection of payments must be through any digital payment method, including bank transfers.
2. Clients must be able to deposit funds into an account on the system as the patient's account is billed for hospital consultations, lab expenses, and medication costs.
3. Dispatching fees are required if a patient agrees to obtain a lab sample from their home or workplace. The same rules apply if the patient chooses to have the medication delivered via dispatch.
4. Cash payments should be prohibited.

Figure 3.4: Process flow of the desired payment system. Source - Researcher



3.5 Platforms

The platform shall combine web and mobile apps with Virtual Hospital, Electronic Health Records (EHR), Telemedicine, and Mobile Health.

3.5.1 Mobile Health

"Medical and public health practice aided by mobile devices," according to the World Health Organization. If a mobile health technology platform is implemented, smartphones and tablets may be used to offer health care and preventative services.

Nevertheless, where does mHealth come into practice beyond formal definitions and theory? As a result, how does mHealth come into play in the real world? Mobile health technology is used by healthcare professionals to:

- Access clinical information (e.g., through mobile health apps and mobile-enabled EHRs),
- Collaborate with care teams (e.g., with secure text messaging),
- Communicate with patients (e.g., through patient portals),
- Offer real-time monitoring of patients, and
- Provide health care remotely, also called telemedicine.

Patients use mobile health technology to:

- Track their health data through mHealth apps and devices like the Fitbit®,
- Access their clinical records through mobile-enabled patient portals, and
- Communicate with their providers (e.g., through HIPAA-compliant e-mail and secure text messaging).

Mobile health technology is also essential in improving patients' health in underdeveloped nations. In 2011, 70% of the world's five billion mobile wireless subscribers were in low- or middle-income countries. In addition, mobile health technology allows government health officials to extend their reach into rural or impoverished areas. For example, 83% of the 112 member states of the World Health Organization have at least one mHealth initiative in their country (Athenahealth, n.d).

3.5.2 Electronic Health Records

Electronic health records are digital versions of a patient's paper chart (EHR). Medical records that may be viewed only by authorized parties are known as electronic health records (EHRs). Patients' medical and treatment histories, in addition to the standard clinical data obtained in the doctor's office, can be stored in an EHR system. As a result, electronic health records (EHRs) are a vital part of health IT and may do the following:

- Allergy and immunization records are also included in a patient's medical records.
- Providers should have easy access to evidence-based tools for making healthcare choices.
- Automate and streamline provider workflow

Patients' medical records are stored electronically in an EHR, where they may be accessed by anybody with access to the system. An electronic health record (EHR) is created around the notion of exchanging information with other health care providers and organizations, such as labs and specialists, medical imaging, pharmacies, emergency facilities, schools, and workplace clinics.

3.5.3 Virtual Hospital

A virtual hospital uses IoT, telemedicine, digital therapeutics, and care navigation technologies to provide continuous remote patient care.

Virtual care is a tried-and-true form of care that assembles a centralized, senior team of clinicians and uses technology to help patients in and out of the hospital. The solution provides caregivers with critical information, allowing them to better care for the patients who require it most and preventing deterioration before it occurs. In addition, virtual hospitals can improve

daily monitoring and care for patients, for example, COVID-19, while limiting exposure to other patients and healthcare workers.

Patients who do not require immediate hospitalization can use a virtual hospital to stay at home, saving money on examination and treatment costs. For one, a remote triage, such as a video conference with a primary care physician, increases access to health care while lowering the cost of emergency room visits.

3.5.4 Telemedicine

In primary care, telemedicine is usually in the form of phone calls, where the patient seeks the doctor's advice about non-emergency medical problems which do not require the doctor to see the patient. Telemedicine does not replace face-to-face consultation when needed but instead complements it.

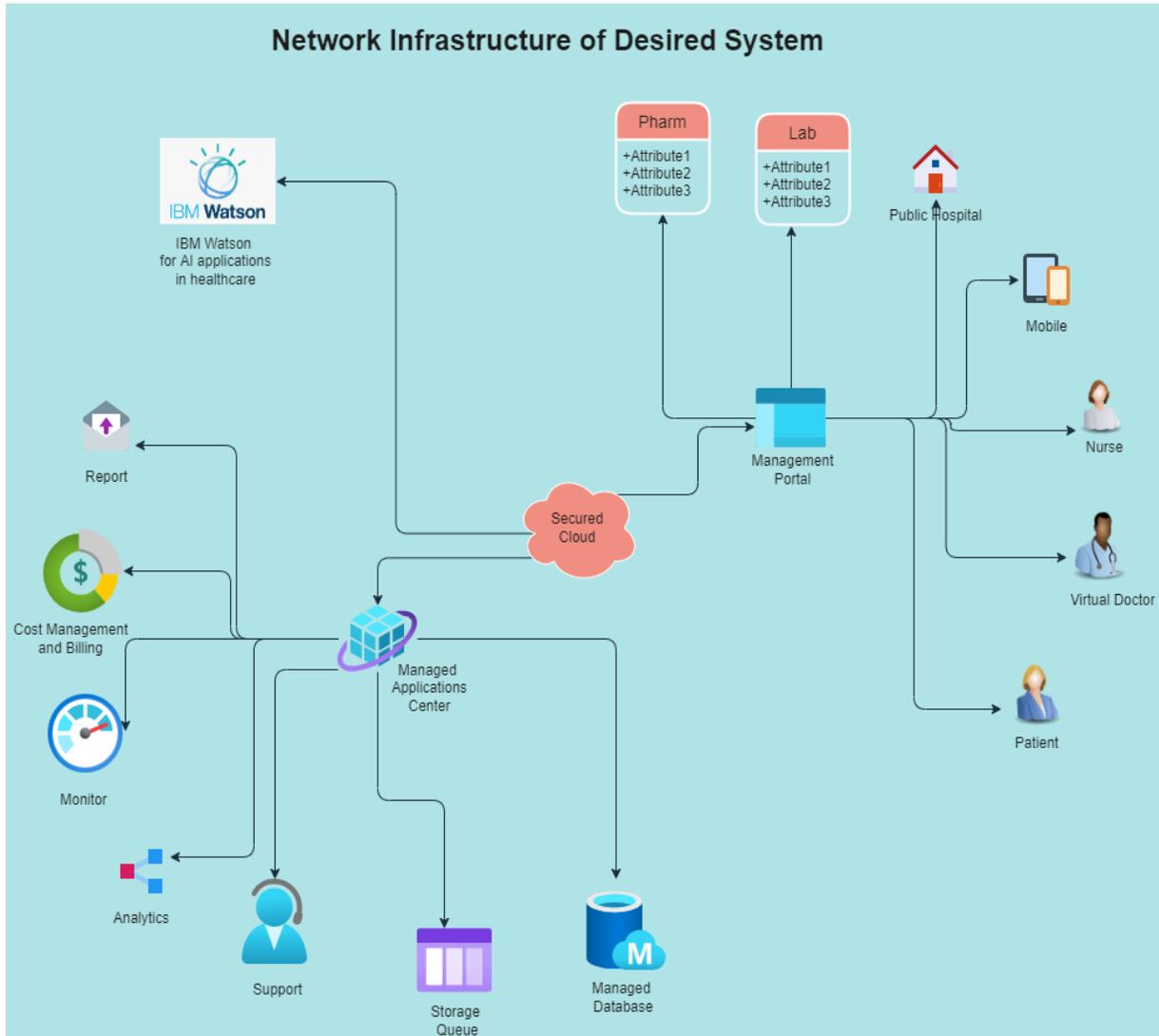
The fundamental role of telemedicine at present lies in its convenience to patients and practitioners by obviating the necessity for a physical visit to get medical advice or treatment. It is also cost-effective compared to waiting to see a doctor or other healthcare provider.

Telemedicine can also help select urgent calls after a doctor's office is closed. It is of immense value in the follow-up of patients with chronic diseases such as diabetes, high cholesterol, or high blood pressure. These individuals who are not experiencing any immediate medical problem but require help with dosage adjustments, lifestyle regimens, prescription refills, or even just access to group support can benefit from the convenience of telemedicine.

An added convenience is that telemedicine consultations can follow all needed laboratory investigations or vital sign monitoring. Doctors have practiced telemedicine for a long time, though not under this name. While this may be true, broadband internet technology has made

both audio and video calls affordable and available to a broader spectrum of society, making this a feasible alternative to the conventional system.

Figure 3.5: Network Infrastructure of the desired system.



Network Infrastructure of the desired system. Credit to the researcher

3.5.5 AI in Healthcare

An "AI in healthcare" system incorporates machine learning (ML) algorithms and other cognitive technologies. Artificial intelligence (AI) refers to the capacity of computers and other devices to learn, comprehend, and act like humans. Using artificial intelligence (AI), computers analyze and act on medical data to make predictions about how something will turn out.

One of the most common uses of AI in healthcare is to aid in medical diagnosis through machine learning and other cognitive sciences. With artificial intelligence and patient data, doctors can create more accurate diagnoses and treatment regimens. In addition, by evaluating massive volumes of data, AI can provide better treatment recommendations for patients, making the healthcare business more proactive and anticipatory.

When AI analyzes healthcare data, the stakes might be life or death. AI may assist healthcare workers, including doctors, nurses, and others, do their tasks more successfully and efficiently. There are several benefits to using artificial intelligence (AI) in healthcare, including better patient outcomes, reduced expenses, and less time spent in the hospital. In addition, artificial intelligence (AI) may be used to predict and track the spread of infectious diseases. Artificial intelligence (AI) has the potential to be a game changer in the fight against illness and pandemics.

The healthcare industry has reached a critical point in its evolution. There are virtually no limits to how technology can help doctors provide more precise, efficient, and successful treatments at the right time in a patient's care (Bresnick, 2018).

With data from electronic health records, physicians may be able to identify patients at risk of infection even before they show symptoms. In addition, machine learning and artificial intelligence (AI) approaches can increase the accuracy of these insights. In today's environment, practically everyone has access to sensors that can provide valuable health data. Wearable devices that can monitor the wearer's heartbeat 24 hours a day and step trackers on smartphones are just two examples of the increasing amount of health-related data gathered on the go.

By utilizing this data, which can augment the information provided by patients via apps and other home monitoring devices, we may better understand the health of both individuals and the public. Using artificial intelligence will be critical in sorting through all this information.

Cellphones and other mobile devices can be valuable for high-quality medical imaging, especially in countries with less technology. Cell phone cameras have steadily grown in quality over the years, and artificial intelligence systems can now evaluate the images recorded with these newer cameras. The early adopters have been dermatology and ophthalmology.

According to experts in the United Kingdom, diagnosing developmental abnormalities in young people is possible by analyzing images of their faces. The algorithm may recognize children's facial features such as their jaw lines, the location of their eyes and noses, and other traits.

3.5.5.1 AI Use Cases in Outpatient Care

We can no longer ignore the importance of artificial intelligence (AI) in healthcare as COVID-19 continues to have a global influence. PwC projects that the AI market for healthcare applications will explode from \$663.8 million in 2014 to \$6.7 billion in 2021, thanks partly to

AI's role in revolutionizing the healthcare business. This rise in demand is because both the complexity and amount of data have grown a lot (Bankovich, 2021).

1. **Patient Prescreening** - Artificial intelligence (AI) may help make patient prescreening more user-friendly than it presently is. Machine learning can help doctors find new trends and better understand patients' symptoms. Natural language processing makes it feasible for potential patient to communicate their symptoms in speech or text to a physician (NLP). As with a doctor-patient relationship, an AI agent and a patient will converse. AI agents may recommend a trip to the ER, a doctor's appointment, or even using the over-the-counter medication as the next step in a patient's medical care. Depending on the patient's location, availability, and insurance information, an AI agent may recommend a medical practitioner to the patient.
2. **Patient Intake** - Improved scheduling algorithms based on digital data developed to better match patients with the correct doctors. AI systems may examine patient intake data to determine if they should be visited by experts right away or whether the fastest therapy is more expedient for them. The nature of patient X and Y's illnesses necessitates that patient Y's evaluation is prime. Emergency hospital wait times in the United States range from two hours in Nebraska to over 14 hours in Puerto Rico. With an AI intake solution, patient care may improve, and ER wait times may shorten. AI may be used to make patient intake less traumatic for patients while simultaneously maximizing the efficiency of medical staff. Healthcare providers can save money on patient data collection costs by reducing the data entry required to digitize medical records.
3. **Diagnosis** - AI's role in medical diagnostics is well-known. In diagnostics and medical imaging applications, AI is well-suited to handle unusual events such as rare diseases. In addition, they are better than most healthcare specialists when identifying complex

patterns. However, taking on medical imaging and diagnostic issues is extremely difficult. In the past, they have used feature creation and engineering (transformation of data to represent or capture concepts as input for a model), but this requires a subject matter expert to perform the task (SME). However, deep learning (DL), a more advanced kind of AI, has the potential to solve some of the most challenging problems in the medical field. For example, medical institutions may free up their highly skilled employees to focus on other activities and serve more patients while also saving time examining medical photos with this artificial intelligence program.

4. **Preventative care** - Preventative care refers to services and procedures that try to prevent future health issues. "Preventive care" now refers only to physical examinations, immunizations, and dental cleaning appointments. AI software can help in preventative medicine. Industrial, automotive, and aerospace companies use sensors as part of their predictive maintenance strategy. Preventive healthcare may promote the use of wearable devices like Fitbit and Garmin. Sensors placed inside these gadgets can track heart rate, exercise intensity, diet, VO₂, and sleep length. A variety of add-ons allow these devices to keep track of a person's weight, blood pressure, and blood sugar, among other vitals. If these wearable gadgets predict health issues before they become a problem, they might be a game changer in preventative healthcare. When a patient crosses a threshold for preventative therapy, these models can deliver real-time wearable sensor data to customers. Wearable data could help doctors learn more about their patients' health problems. That could lead to better care and less time spent on the patient's symptoms and medical record.

3.5.5.2 IBM Watson in Patient Care

IBM Watson Health's clinical decision support (CDS) solution uses artificial intelligence to help doctors offer personalized, evidence-based care. Clinical decision-making can be influenced by integrating electronic health records (EHRs) with mobile-friendly solutions for healthcare professionals working in clinics or on the road.

Fragmented patient data and rapidly evolving studies have made it challenging for physicians to gain critical insights into their patients' health. Watson AI can quickly get important information from the EHR or the latest scientific literature. That helps doctors make better decisions and improves the patient experience.

Figure 3.6: All-in-one clinical decision support



Clinical enterprise solution featuring evidence-based drug and disease content, AI-powered search capabilities, and cloud-based tools – all within a single, point-of-care solution suite. Source: IBM Watson

Figure 3.7: AI-enabled drug information reference database



Put the power of Watson AI to work and get fast, reliable information on drugs, disease, toxicology, and alternative medicine in the clinic or on the go. Source: IBM Watson

Figure 3.8: AI clinical decision support for imaging



The clinician-trained solution helps radiologists identify underlying issues by efficiently extracting and summarizing patient data from electronic health records (EHR). Source: IBM Watson

A shift away from fee-for-service approaches in healthcare is reducing the use of reactive care. Healthcare providers can already set up the processes that will allow proactive, predictive

therapy for chronic diseases, expensive acute events, and sudden deterioration because of how reimbursement systems work. The power of artificial intelligence systems can help detect diseases like seizures and sepsis before they become life-threatening.

It is in everyone's interest when artificial intelligence (AI) is used in the healthcare industry since it can streamline processes, aid medical and non-medical personnel with routine jobs, speed up user questions, and help create new treatments and therapies. To satisfy the high demand of patients in Sub-Saharan Africa who would utilize the Smart OPD, IBM Watson is included in the proposed system's network architecture, making it feasible for the proposed system's virtual physicians to fulfill the high demand of patients quickly.

Chapter 4: Evaluation, Control, and Discussions

4.1 Delivery Management

The development of an app must first be a plan and the necessary money. Then, developing, implementing, and evaluating application procedures is necessary to obtain the required outcomes. Efforts will be more fruitful if the app and corporate strategy sync.

The way to approach an app may significantly influence its success. Consequently, a company's overall strategy, marketing tactics, and ability to generate income will be enhanced. For example, applications can be divided into stages to track internal operations.

4.1.1 Delivery to the cloud

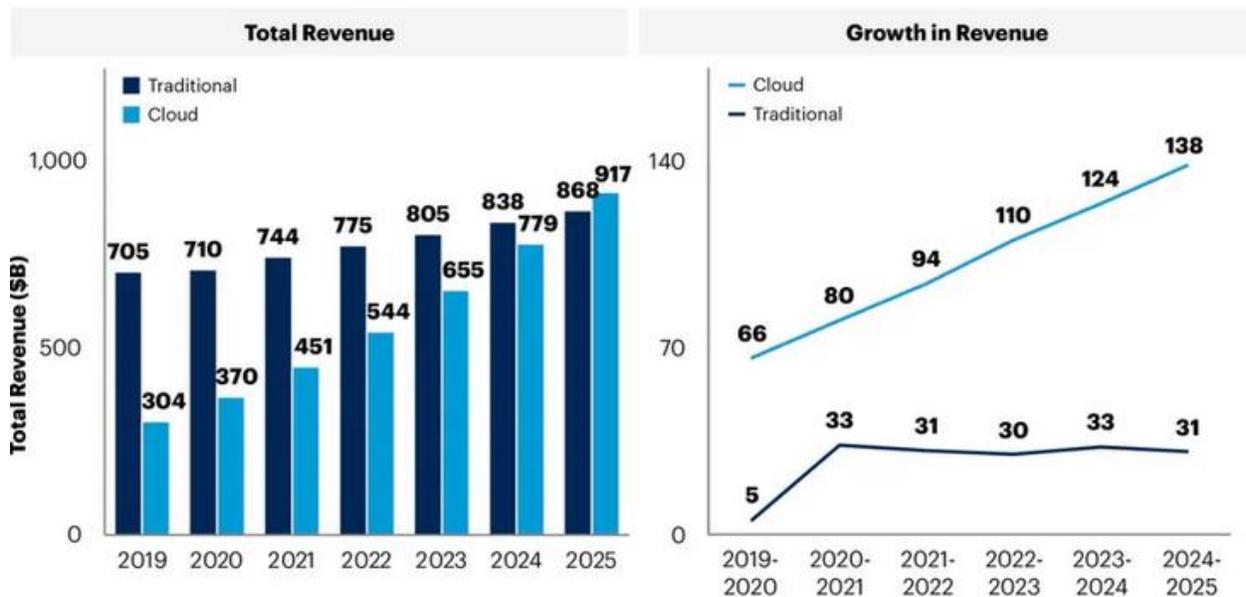
As seen in Chapter 3's network infrastructure, Gartner believes that the cloud is now the dominant platform for business computing. For less money and faster speed, cloud computing makes it feasible to provide many computer services such as server hardware/software/storage/databases/networking/analytics/intelligence through the Internet (the "cloud").

Instead of building a data center or infrastructure, a company may use a service provider's cloud services, such as applications and storage. By using cloud computing services, businesses

may avoid the up-front expense and complexity of creating and maintaining their own IT infrastructure. Instead, they only pay for the services they use and only for the time they spend using them. As a result, IT investment is shifting from traditional, in-house systems to cloud computing, whether a vendor's public cloud service or a private cloud built internally by an organization.

For the first time, Gartner predicts that more than half of the investment in application software, infrastructure software, business process services, and system architecture will be via the cloud by 2025. By 2022, cloud computing will account for over two-thirds of all application software spending, up from 57.7 percent, according to IDC (Foley, 2022).

Figure 4.1: Sizing Cloud Shift, Worldwide 2019 – 2025. Source - Gartner



A paradigm shift in computing has occurred with the introduction of cloud computing. Creating a Smart OPD on the cloud, according to the study, is vital to stay up with the current

technological trend and make use of its benefits. In addition, slashing expenses requires being able to grow while maintaining data coherence and flexibility.

The usage of cloud computing considerably speeds up the creation of mobile apps. Therefore, using a cloud is strongly advised while designing custom software. Why? Following this process will ensure that the app is based on the company's original concepts and serves customers correctly. In addition, as more software developers go to the cloud, this will make it easier for customers to interact with their apps soon.

4.2 Evaluation and Control

Cloud computing has moved the digital transformation process ahead. As a result, concern over the pandemic's influence on business operations has decreased. Because of the improved knowledge of the issue, firms may move forward. Workforce management and a mobile workspace are the most common reasons companies rely on the cloud for their business operations. The following factors is taken into consideration while researching and choosing cloud service providers for the Smart OPD:

- SLAs
- Technology stack
- Pricing
- Security and compliance.

These are all essential concerns regarding performance and accessibility.

4.2.1 Performance and Availability

Because the end-user experience is crucial to many organizations, cloud suppliers must be able to maintain performance even in a globally distributed system. However, with so many third-party components and links in the delivery chain, it is challenging to monitor application performance at every point (Kareem, 2020).

Many factors can influence cloud-hosted applications' performance, availability, and reachability. The cloud service provider must supply an understanding of network metrics, such as latency, throughput (in milliseconds per request), and response times at every critical point in the service. This data and end-to-end visibility are critical for monitoring performance and service availability. When evaluating service providers, inquire about their responsiveness and availability.

- The average response time of a system is how long? An application's response time takes after receiving a user request.
- Does the service provider offer geo load balancing to distribute application requests across many cloud resources?
- How well is the cloud service provider utilizing its resources?
- Does the vendor provide monitoring tools, or can they work with an external platform? Furthermore, how well do these DEM systems connect with the current monitoring strategy?

Knowing how much control and insight the seller gives a customer into third-party services is essential.

4.2.2 Reliability and SLAs

SLAs based on network performance is relatively widespread among cloud service providers. If a service outage or disruption occurs, these SLAs will safeguard consumers. SLAs must be maintained to ensure that the service is reliable, and that the quality of service is maintained. The vendor's responsibilities are evident in the contract in the case of a service failure. That is more than a simple system health dashboard; the vendor needs actual service reliability data to ensure the potential provider is maintaining the required uptime criteria. When comparing different cloud service level agreements, keep the following points in mind:

1. The service and delivery definitions must be clearly understood.
2. A thorough understanding of each service's responsibilities (provisioning, monitoring, and support)
3. It is critical to know how disaster recovery and service availability operate together.
4. It is essential to know if they align with the company's priorities.
5. Knowing whether the vendor allows customers to see performance statistics at the breach of an SLA is crucial.

4.2.3 Technology Stack and Cost

These firms have transitioned from infrastructure as a Service supplier to platform as a Service provider (PaaS). Cloud platforms that match the application's technology stack make it

much easier to offload infrastructure setup, configuration, and maintenance. The engineers will heavily rely on the cloud vendor's technology, such as a robust database, serverless services, artificial intelligence, and machine learning. Consider the following considerations while choosing a cloud computing service provider:

1. In what ways may a user's account be managed?
2. To what extent is it possible to influence a company's infrastructure?
3. It is essential to know what the vendor can provide for developers.
4. Is the vendor's community of developers and customers active and engaged?
5. Is it possible for other parties to alter and integrate it?

Cloud service providers have a wide selection of services available since they provide several pricing alternatives. SaaS-based services determine pricing by the time the service is used – per user/month basis, the quantity of data kept, advanced capabilities, and other adjustable factors. There are two pricing models for cloud computing services: one for PaaS and one for IaaS.

4.2.4 Security and Compliance

Regarding going to the cloud, security and compliance are critical considerations for enterprises. The company's security policies must adhere to when using a cloud service. There must be the following security elements available in a cloud service provider:

1. Protection and encoding of sensitive data.
2. An offer for serverless security in a multi-tenant PaaS system.
3. Therefore, it is vital to keep the network secure.

Vendors must present complete incident and audit reports and be certified. Tracking user activity and granting access privileges and security to each job is also essential. Suppose they want to utilize more than one cloud service. In that case, they may want to investigate a third-party cloud security solution, even though the most respected providers offer comprehensive security features.

Fig 4.2 depicts a typical cloud security plan and the terms mentioned in the advanced security section described below:

1. SaaS-based cloud applications necessitate the use of CASBs.
2. The discovery of Cloud security posture management may as risks and compliance breaches (CSPM).
3. With the help of CWPPs, IaaS installations are safe.
4. The Secure Access Service Edge (SASE) architecture is a standard option for cloud security solutions.

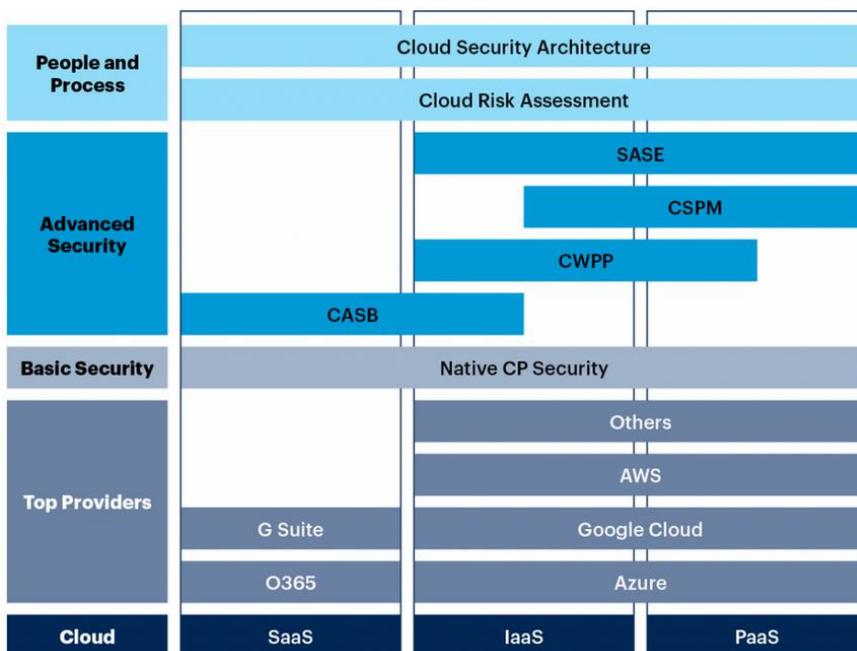


Figure 4.2: Cloud security strategy across different types of cloud services providers. Source - Catchpoint

Cloud computing's advantages go well beyond saving money on infrastructure. Cloud platforms enable distributed multi-tenant infrastructure by providing a rich developer experience, scalable network services, comprehensive security, and regulatory compliance needs. Cloud platforms also support distributed multi-tenant infrastructure. Platforms in the cloud Offerings from leading cloud service providers include the following:

1. Multifaceted set of tools and methods
2. Governance and management of data
3. Instruments of sifting
4. Services and support for those who are moving
5. Managing infrastructure is a breeze.

It is easy to get overwhelmed by all the options for services, advanced features, and other capabilities available from suppliers. The company should compare cloud service providers based on the above criteria if they want to implement a new cloud migration or a multi-cloud system.

4.3 Stakeholder Analysis

It is possible to do stakeholder analysis using a wide range of techniques and tools, and they may be used to assess the needs and desires of important stakeholders both within and beyond the project context. The project manager can better plan the project if there is an idea of how the supporters and detractors interact. Whether or not the initiative will succeed depends on the level of support receive here.

Table 4.1: Shows the stakeholder analysis of the Smart OPD project. Source: Researcher

| |
|---|
| <p>Organizational Background:</p> <ul style="list-style-type: none">• What is the organization?• What does it do?• What are the offered products or services? |
| <p>Act 525 of 1996 established the Ghana Health Service (GHS) as a public service organization, as required by the 1992 constitution. Accompanied by the Ministry of Health, the Ghana Health Service Council is an autonomous Executive Agency that administers national policy.</p> <p>As part of the 1990s' main initiatives, the inclusion of GHS in the Health Sector Reform's medium-term strategy and the five-year plan was for 1997-2001. Without these efforts, a more equitable, efficient, accessible, and responsive healthcare system would have been impossible.</p> |
| <p>Mandate</p> <p>The health care system should be comprehensive and accessible, focusing on primary care at the regional, district, and sub-district levels.</p> |
| <p>Vision</p> <p>All communities have access to timely, quality, and comprehensive health care.</p> |
| <p>Motto</p> <p>Your health is our concern</p> |
| <p>Objectives</p> |

- Implement national policies for health delivery in the country
- Increase access to high-quality health care and
- Manage resources wisely

Functions of the Service

- They are providing or contracting out neighborhood, subdistrict, district, and regional health care services to ensure people have access to health care.
- They are developing technical recommendations to ensure the achievement of MOH policy requirements.
- Management of various health care services, with an emphasis on primary care
- Devising methods for distributing healthcare resources equally among rural and urban areas
- Managing and overseeing the service's medical facilities
- Relying on the expertise of medical schools to treat referred patients
- Healthy life and excellent health practices are encouraged by individuals.
- Monitoring and controlling the spread of diseases is an essential part of public health.
- In-service and ongoing education for healthcare professionals is key to their success and success as a profession.
- Managing the service's assets and properties to maximize their value
- Determining, with the Minister of Health's consent, the fees the service will charge for health services
- Maintain, improve, or restore one's health in any other way

Influential Stakeholders:

- Which of the organization's stakeholders are considered the most significant influencers that impact the success or failure of the organization?
- Group influential stakeholders by their interests and power level.

Those who are interested in or affected by the project are called stakeholders. Therefore, a plan for interacting with stakeholders at an early stage is necessary for the project's definition and growth (Usmani, 2019).

The biggest influencers are;

Internal**1. Ghana Health Service Council**

- a. Interest – To ensure equity among parties such as government, management, and industry players.
- b. Power level – Assume the role of a business owner with Authority over management.

2. Management

- a. Interest – To satisfy the Ministry of Health, Government, and the General public and make a profit.
- b. Power level – Power over staff to ensure workflows effectively.

3. General staff

- a. Interest – Complete scheduled task

External

4. Government / Ministry of Health
 - a. Interest – To provide quality and affordable healthcare, reduce fraud in the industry and maximize revenue.
 - b. Power level – State-owned with 100% shares

5. Industry players (Private healthcare Providers / Suppliers)
 - a. Interest – To support and expand healthcare delivery and maximize profit
 - b. Power level – Hold power as partners in healthcare delivery and suppliers of healthcare products.

6. The General public
 - a. Interest – Takes the role of patients interested in quality and affordable healthcare and access to healthcare centers.
 - b. Power level – Power to vote against the government if patients are dissatisfied.

To begin, think about who would be interested in knowing more about the stakeholders. It is critical to involve not only people who have power over the work but also those who have an interest in it. Ultimately, companies and individuals can communicate with one another and with other interested parties. The constituted board of a stakeholder institution should be of the right individuals (Bdaiwi, 2017).

Using a simple tool, such as the **Interest / Power matrix**, a reliable overview of stakeholder influence is as follows;

| | | | |
|-------|------|------------------------|-----------------------|
| | | Level of interest | |
| | | Low | High |
| Power | Low | A Minimal Effort | B Keep Informed |
| | High | C Keep Satisfied | D Key Players |

Interest and power level

- Government – High interest and high power (Key Player)
- Ghana Health Service Council – High interest and high power (Key Player)
- Management - High interest and high power (Key Player)
- National Health Insurance Scheme – High interest and low power (Keep Informed)
- Private Sector / Supplier – High interest and high power (Key Player)
- General staff – Low interest and low power (Minimal Effort)
- General public – Low interest and high power (Keep Satisfied)

Stakeholder Attitudes:

- What are the positive and negative attitudes of stakeholders toward the organization?

Many stakeholders support the project with satisfaction, while others dislike it and ignore it. (Bourne, 2015).

Positive

- Stakeholders provide good feedback during stakeholder engagement

- Report malpractices of some general staff and suppliers to the Health Administration and Support Services for action
- The government pays subsidies on some selected drugs and products to the patients.
- The National Health Insurance Scheme pays for some selected healthcare services on behalf of the patients.

Negative

- The general staff frequently demonstrates unfair policies and wages.
- The private sector and suppliers are unhappy with policies and projects that favor public sector health workers.
- Political opposition parties play politics with the policies and projects and blame the government for the unfair treatment of public health workers and citizens.
- Suppliers disregard safety standards.
- Indirect political control of management with regards to hiring and promotions.

Communication Plan:

- What is the organization's communication plan to relay important information on projects and ventures to key stakeholders?
- How do individual stakeholders' varying needs and interests impact the communication plan?

| Communication Plan | | | | |
|----------------------|-----------------|------------------|---------------|-----------------|
| Description | Frequency | Method | Audience | Owner |
| Project team meeting | weekly | Meeting | Project Team | Project Manager |
| Stakeholder update | Quarterly | Email newsletter | Stakeholders | Project Manager |
| Board meeting | Every two weeks | Meeting | Board members | Board Secretary |

| | | | | |
|---|-----------|-----------------------|-------------------|-----------------|
| Contribution to the department newsletter | Weekly | Section of newsletter | Wider development | Project Manager |
| Staff durbar | Quarterly | Audio conference | Staff | HR Manager |

Impact

- Members of the various groups engage in other groups and cannot participate in meetings.
- Some members lack internet access to receive notifications promptly
- Lack of devices to join audio and video conference.

Corporate Social Responsibility (CSR):

- What CSR programs is the organization involved in, or what is its CSR approach?
- Which stakeholders have the most influence over the organization’s CSR?

CSR approach

The Ghana Health Service (GHS) has received donations from other government agencies, commercial enterprises, and members of the public through its Teaching, Regional, and District hospitals.

Most influential stakeholders

The stakeholder with the most influence over the organization is;

- Government / Ministry of Health
- Ghana Health Service Council
- Management

4.4 Discussions

In support of the findings and suggestions of the researcher, this part examines the perspectives of a select group of stakeholders on the Smart OPD initiative.

4.4.1 Doctor's point of view

An expert from Mountain View Community Hospital located at Kasoa in the central region of Ghana, says that the Smart OPD as a virtual hospital would build an efficient healthcare route, use technology that significantly reduces hospital footfall and patient wait times, and achieve system-based cost reductions. That shows that most patients receiving virtual specialist care can be handled in a community setting or remotely. Her main fear is how virtual physicians would be able to examine a patient with a stethoscope?

4.4.2 Pharmaceutical point of view

It would prevent many people from going through congested traffic to visit a laboratory or a pharmacy, says Mr. Benjamin Botwe, a former president of the Ghana Pharmaceutical Association of Ghana. As he sees it, the public and pharmacists will welcome this new method. According to him, the pharmaceutical council intends to create a database that would link all the country's pharmacies together, allowing them to keep track of medicine inventories and deliveries in real time. This solution, he asserted, will be a valuable addition to the business once integrated with their envisioned database.

4.4.3 Nurse's point of view

Nurse burnout has made it even more challenging to find qualified healthcare professionals. Nurses may abandon their employment due to mental and physical exhaustion or weariness. Telehealth technology has made it possible for fewer nurses to deliver appropriate treatment, reducing some of the pressure on the profession. In addition, technological advancements and new technologies have helped patients and healthcare practitioners (Avant Health Professionals, 2019).

In a conversation with the VRA hospital's Principal Nursing Officer, Mrs. Gifty Adusei-Agyemang, she recognized that the Smart OPD would significantly cut wait times and improve patient-nurse interactions. However, if adopted by the government, she believes the initiative would create jobs for the jobless nurses and provide additional revenue for the already working nurses. Moreover, she said that this would increase productivity and enhance the economy since workers would no longer have to leave the office to visit the hospital for lengthy periods.

4.4.4 Entrepreneurial point of view

A new entrepreneur may solve many challenges if he or she learns from various sources. For example, time, money, and effort can be a waste when a company's product or service does not address the needs of another company's customers. Therefore, an entrepreneur must first identify a problem that needs a solution before launching a business (Hayes, 2021).

The capacity to establish new businesses from preexisting concepts, ideas, or principles is sometimes called entrepreneurship. There has been a significant entrepreneurial reaction to advances in healthcare service delivery's scientific and social underpinnings.

According to a Ghanaian entrepreneur Mr. Elvis Adusei-Agyemang, there are already enough nurses and a delivery service business ready to collaborate with pharmacies and labs to provide this service. Therefore, he added that investing in a system that utilizes a small number of doctors, and many nurses is worthwhile.

Chapter 5: Summary, Conclusion, and Recommendations

This thesis indicates final thoughts and recommendations as an overview of this dissertation's findings and conclusions. The primary purpose was to design a contemporary technical management method to offer excellent healthcare to the people of Sub-Saharan Africa without the queue limits, which is a crucial hindrance to quality healthcare.

5.1 Summary

Reduce or eliminate long wait times in the outpatient department by increasing the efficiency of public healthcare institutions in Sub-Saharan Africa. For this, the researcher looked at specific operational concerns, such as:

4. Current system issues for hospital administrators
5. Stakeholder concerns about hospital innovation
6. Investment outcome in new technology and retooling outdated procedures.

While undertaking creative initiatives in Sub-Saharan Africa, it provided new solutions for public healthcare facilities resulting in answers to the following questions.

1. What are some of the most popular modern technical applications in the developed world?

2. Is there a way to use the advantages of these new platforms?
3. What consideration should be made when making use of these software platforms?
4. How can public healthcare institutions in Sub-Saharan Africa transform the face of healthcare delivery by adopting an innovative technology management strategy and strategic model?
5. Is it possible to create an enormous number of new jobs by utilizing this model?

Since COVID-19 was released, telemedicine and remote monitoring have seen significant advancements. Healthcare innovation is critical for strengthening patient care, ensuring safety, boosting productivity, and lowering costs. A plethora of issues needs to be addressed while implementing new concepts for hospital discharge processes. Innovative solutions should be data-driven and evidence-based, resulting in high-quality healthcare delivery options. ' Oregon Medical Group, Oklahoma University Medical Center, and St. Vincent Healthcare are used as case studies by the researcher to demonstrate how healthcare modernization handles legacy issues.

1. Oregon Medical Group employed a real-time location system to solve a workflow problem. As a result, the healthcare workflow solutions reduced patient wait times by 75% while increasing treatment times by 50%.
2. Oklahoma University Medical Center's lab used robotics and computer technology for nine months to decrease K+ outlier rates from 18% to less than 3% on several chemistry exams. In addition, it tested all specimens in real time to prevent the need for TAT testing.
3. Management at St. Vincent's Hospital used Tele pharmacy solutions to supply medication to valid patients. As a result, prescriptions were filled in as little as 10

minutes at the Wheatland Memorial pharmacy, allowing patients to go back on their way in record time.

5.2 Conclusion

Investing in long-term healthcare outcomes and optimizing investment returns while developing the African healthcare sector necessitates international cooperation involving public, private, and development partners. Competition in the health care industry benefits the private sector at the expense of public institutions, which continue to lag. Investing in cutting-edge technologies can provide a short-term advantage over the developed world.

Quite a few public hospital doctors also split their time between private practices. The executive class exclusively visits private healthcare facilities because of the high expense of healthcare. According to the Journal of Health Affairs, healthcare must be cost-effective rather than pricey. Patients of various socioeconomic backgrounds will be able to get healthcare thanks to a new strategy proposed in this dissertation.

Private hospitals have changed their operations by using Electronic Health Management Systems (EHM), allowing them to treat their patients in shorter amounts of time. However, information technology can help hospitals and other service providers improve their offerings. Some examples of how information technology may help people make better health decisions include promoting individual and population-based preventative initiatives and enhancing public health collaboration.

To keep track of public health and disease surveillance, an advanced health information system should be in place. It is critical to integrate systems and processes to identify new health concerns and provide information to all stakeholders so that they may make well-informed

decisions. Building an NHII should be a national goal if the public healthcare sector faces a similar digital transition as banks and other businesses.

One of the most important points raised during the Africa Health Business Symposium was the need for healthcare reform across Africa. These are examples of healthcare finance, as is the development of human healthcare resources, supply chain management, and digital technology use. Connectivity-based digital technology advances have impacted every sector.

Because of a scarcity of well-qualified medical professionals, the healthcare industry in Africa is affected by a supply-and-demand imbalance and inadequate facility management. In addition, several African countries subsidize the education of medical professionals and nurses outside of their borders because of a lack of resources at home. Because of this, Africa's health industry is seeing a "brain drain," as newly trained professionals leave the continent searching for better working conditions and higher salaries overseas.

For the governments of Sub-Saharan Africa to improve and speed up healthcare delivery, an A3 Report and Functional Analysis in chapter 3 found the requirement of technology investment by the government. In addition, Chapter 3 also showed a root cause analysis, that a lack of adequate infrastructure is a crucial contributor to the public healthcare system's woes.

To better understand the potentially lethal delays, the researcher investigated their root causes. A new strategy to speed up care for patients in the Outpatient Department is required. To reduce the number of patients who must go to public hospitals, the Smart OPD System will help the health service by providing virtual and physical care to some patients. Physicians, nurses, and patients will no longer be afraid to perform medicine following the Covid-19 outbreak.

5.3 Directions for Future Research

Digital healthcare relies heavily on artificial intelligence (AI). The researcher discussed AI's significance to the Smart OPD concerning its integration. First, practitioners must prepare to take on digital challenges in the domain of artificial intelligence. As a continent, the government, people, and healthcare professionals in Sub-Saharan Africa need to be studied to see if they are ready for AI adoption and how it will affect their jobs.

5.4 Recommendations

1. Stakeholders must be interested in systems that will seek to reduce patient wait time. That investment will lead to a healthy economy capable of promoting economic growth.
2. The Smart OPD introduced by the researcher will create a centralized digital healthcare system. Ghana, on the other hand, has laid the groundwork for a completely decentralized healthcare system throughout the years. There should be a legal and regulatory framework for the health sector to administer both the centralized and decentralized healthcare system.
3. Ghana's Ministry of Health created a bonding policy that prevented nurses from leaving the country after training for five years. The policy has created an overflow of nurses to overcome the challenges of the West African nurse shortage. Health ministers in Sub-Saharan Africa must deploy the same policies and use virtual technologies in healthcare to create jobs to cater to the overflow.

4. Governments should partner with internet service providers to make the internet accessible at all public health centers to serve as the digital foundation for expanding digital infrastructure, thereby reducing the physical infrastructure deficit. Also, invest in health facility electrification to sustain widespread broadband internet access.
5. Training medical professionals in e-learning tactics is a great way to ensure they are ready to employ increasingly advanced technology. In addition, involve local community health leaders to hasten the adoption and utilization of 4IR technology.
6. Low- and middle-income countries in Sub-Saharan Africa have limited access to healthcare services due to poverty, low educational attainment, a lack of healthcare professionals, and inadequate healthcare infrastructures. Therefore, governments must seek funding to make digital healthcare accessible to all.
7. Digital health technologies and therapies are being used in sub-Saharan Africa's youthful population to improve their health and well-being, according to our dialogue. There should be support from major global organizations like the UN and the WHO. In addition, stakeholders must address individual barriers, such as a lack of computer literacy and connectivity in the regions.
8. It is in everyone's interest when artificial intelligence (AI) is used in the healthcare industry since it can streamline processes, aid medical and non-medical personnel with routine jobs, speed up user questions, and help create new treatments and therapies. Therefore, medical practitioners in Sub-Saharan Africa should be encouraged to take training courses in AI for healthcare.

References

Nell Lewis (October 15, 2019) Drones, apps, and smart lockers: The technology transforming healthcare in Africa. Retrieved from: <https://edition.cnn.com/2019/10/15/tech/tech-africa-healthcare/index.html>

Jess Holder (2021) Innovation in healthcare delivery, 2021. Retrieved from: <https://dhge.org/about-us/blog/innovation-in-healthcare-delivery>

Linda V. Green (2008) Using Operations Research to Reduce Delays for Healthcare. Retrieved from: https://www0.gsb.columbia.edu/mygsb/faculty/research/pubfiles/3874/OR%20in%20Healthcare_LindaGreen.pdf

Ghana Health Service (June 2017) 2016 Annual Report. Retrieved from: <https://www.moh.gov.gh/wp-content/uploads/2017/09/2016-Annual-Report.pdf>

NOI Polls (December, 2018) Most Nigerians Have Visited Public Hospitals and Pharmacies Over The Last Year. Retrieved from: <https://noi-polls.com/most-nigerians-have-visited-public-hospitals-and-pharmacies-over-the-last-year/>

WHO (June 23, 2020) Medical doctors (per 10 000 population). Retrieved from: [https://www.who.int/data/gho/data/indicators/indicator-details/GHO/medical-doctors-\(per-10-000-population\)](https://www.who.int/data/gho/data/indicators/indicator-details/GHO/medical-doctors-(per-10-000-population))

Igoni and Yenagoa (January 23, 2020) Nigeria's doctor-patient ratio is 1:3,500 – NUC. Retrieved from: <https://punchng.com/nigerias-doctor-patient-ratio-is-13500-nuc/>

Partners In Health (July 25, 2017) Iconic Hospital in Malawi to Expand. Retrieved from: <https://www.pih.org/article/iconic-hospital-in-malawi-to-expand>

Ari B. Naim (November 9, 2018) Automation through RTLS can transform patient care. Retrieved from: <https://www.healthcarefacilities.com/posts/Automation-through-RTLS-can-transform-patient-care--19913>

Mohammad Karim Bahadori, Ehsan Teymourzadeh, Ramin Ravangard, and Mehdi Raadabadi (April 2017). Factors affecting the overcrowding in outpatient healthcare. Retrieved from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5433641/>

By Dr. George Kanani (September 2016). Tanzania: Technology Can Solve Long Queues at the Hospital. Retrieved from: <https://allafrica.com/stories/201609191116.html>

Lauren Salmon (May 23, 2017) The importance of case studies in social research. Retrieved from: <https://www.changeworks.org.uk/news-and-events/blog/the-importance-of-case-studies-in-social-research>

H J Anderson et al. (August 5, 1990) Outpatient care: a nationwide revolution. Retrieved from: <https://pubmed.ncbi.nlm.nih.gov/2373495/>

Health Business Symposium (October 31, 2017) Healthcare Revolution in Africa through Public-Private Partnerships. Retrieved from: <https://healthmanagement.org/c/hospital/post/healthcare-revolution-in-africa-through-public-private-partnerships>

Patrice Matchaba (January 11, 2018) How new tech can propel Africa to the forefront of healthcare. Retrieved from: <https://www.weforum.org/agenda/2018/01/africa-lead-healthcare-fourth-industrial-revolution/>

Professor Landry Signé (October 2021) Strategies for adequate health care for Africa in the Fourth Industrial Revolution. Retrieved from: https://www.brookings.edu/wp-content/uploads/2021/10/Strategies-for-effective-health-care-delivery-in-Africa_FINAL.pdf

New Africa (March 23, 2019) Healthcare revolution is underway. Retrieved from: <https://newafricanmagazine.com/20192/>

Dr. Simone Sandholz (December 06, 2020) Five things you need to know about health infrastructures. Retrieved from: <https://ehs.unu.edu/news/news/five-things-you-need-to-know-about-health-infrastructures.html>

Sammy Darko (February 27, 2015) How Ghana has reversed the exodus of nurses. Retrieved from: <https://www.bbc.com/news/world-africa-31637774>

Dr. Jean Baptiste ROUNGOU and Dr. Maria Neira (February 2010) Public Health and Environment in

the African Region. Retrieved from: <https://www.afro.who.int/sites/default/files/2017-06/phe2008-2009-fin.pdf>

World Health Organization (2016) Towards improving access to medical devices through local production Phase II. Report of a case study in four sub-Saharan countries. Retrieved from: <https://apps.who.int/iris/rest/bitstreams/916442/retrieve>

International Finance Corporation (April 2021) Helping Africa Secure Essential Medical Equipment. Retrieved from: https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/essential-medical-equipment-and-covid-19-africa

World Health Organization (2016) Towards improving access to medical devices through local production Phase II. Report of a case study in four sub-Saharan countries. Retrieved from: <https://apps.who.int/iris/rest/bitstreams/916442/retrieve>

Giacomo Falchetta, Ahmed T. Hammad, and Soheil Shayegh (November 30, 2020) Planning universal accessibility to public healthcare in sub-Saharan Africa. Retrieved from: <https://www.pnas.org/doi/10.1073/pnas.2009172117>

Felix Sukums and Friends (April 2020) Sub-Saharan Africa—the new breeding ground for global digital health. Retrieved from: [https://www.thelancet.com/journals/landig/article/PIIS2589-7500\(20\)30027-3/fulltext](https://www.thelancet.com/journals/landig/article/PIIS2589-7500(20)30027-3/fulltext)

Keneilwe Sadie Mooketsane and Molefe B Phirinyane (December 2015) Health governance in Sub-Saharan Africa. Retrieved from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4639823/>

Bernard F Couttolenc (June 2012) Decentralization and Governance in the Ghana Health Sector. Retrieved from: <https://elibrary.worldbank.org/doi/abs/10.1596/978-0-8213-9589-9>

Shaw, R. Paul; Griffin, Charles C. (May 1996) Cost Sharing: Towards Sustainable Health Care in Sub-Saharan Africa. Retrieved from: <https://openknowledge.worldbank.org/handle/10986/9967?locale-attribute=en>

Iwelunmor et al. (March 23, 2016) Toward the sustainability of health interventions implemented in sub-Saharan Africa: a systematic review and conceptual framework. Retrieved from: <https://implementationscience.biomedcentral.com/articles/10.1186/s13012-016-0392-8#Sec23>

Centrak (n.d) Outpatient Workflow Automation at Oregon Medical Group. Retrieved from: <https://centrak.com/resources/case-studies/oregon-medical-group>

Kenneth E Blick (January 1, 2008) A case study of the laboratory: the most important department in the hospital? Retrieved from: <https://hospitalhealthcare.com/news/a-case-study-of-the-laboratory-the-most-important-department-in-the-hospital/>

Scot Mitchell, Marjorie Nafts (n.d) Case Study: An Automation Solution for Rural Outpatient Pharmacy Services. Retrieved from: https://www.pppmag.com/article_print.php?id=2

WHO and UNICEF (2020) Operational Framework for Primary Health Care. Retrieved from: <https://apps.who.int/iris/rest/bitstreams/1321790/retrieve>

Kumah & group (December 20, 2021) Framework for assessing the performance of the Ghanaian health system: study protocol. Retrieved from: <https://health-policy-systems.biomedcentral.com/articles/10.1186/s12961-021-00802-1>

International Trade Administration (n.d) Ghana - Country Commercial Guide. Retrieved from: <https://www.trade.gov/country-commercial-guides/ghana-healthcare>

James Lind Institute (August 5, 2019) Public Health Services in Ghana. Retrieved from: <https://www.jliedu.com/blog/public-health-services-ghana/>

Athenahealth (n.d) What is mobile health technology? Retrieved from: <https://www.athenahealth.com/knowledge-hub/healthcare-technology/what-is-mobile-health-technology/healthcare>

Jennifer Bresnick (April 30, 2018) Top 12 Ways Artificial Intelligence Will Impact Healthcare. Retrieved from: <https://healthitanalytics.com/news/top-12-ways-artificial-intelligence-will-impact-healthcare>

Shawnasty Bankovich and Stephanie Rivera (January 18, 2021) Six Use Cases for Artificial Intelligence in Healthcare. Retrieved from: <https://www.credera.com/insights/six-use-cases-for-artificial-intelligence-in-healthcare>

IBM (n.d) Clinical decision support software solutions with AI. Retrieved from: <https://www.ibm.com/watson-health/solutions/clinical-decision-support>

Mary Jo Foley (May 31, 2022) What is cloud computing? Everything you need to know about the cloud explained. Retrieved from: <https://www.zdnet.com/article/what-is-cloud-computing-everything-you-need-to-know-about-the-cloud/>

Kameerath Kareem (September 11, 2020) Evaluating Cloud Service Providers. Retrieved from: <https://www.catchpoint.com/blog/how-to-evaluate-cloud-service-providers>

Fahad Usmani (December 2019) Stakeholders in Project Management. Retrieved from: <https://pmstudycircle.com/2012/03/stakeholders-in-project-management-definition-and-types/>

Yaman Bdaiwi (Mar 2017) Stakeholder Analysis using the Power Interest Grid retrieved from <https://www.projectmanagement.com/wikis/368897/Stakeholder-Analysis--using-the-Power-Interest-Grid>

Adam Hayes (November 12, 2021) Entrepreneur. Retrieved from: <https://www.investopedia.com/terms/e/entrepreneur.asp>

Avant Healthcare Professionals (September 10, 2019) How Technology is Impacting Nursing Practice in 2020. Retrieve from: <https://avanthealthcare.com/blog/articles/how-technology-is-impacting-nursing-practice-in-2019.shtml#>